Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
	)	
Streamlining Licensing Procedures for Small Satellites	)	IB Docket No. 18-86
	)	

COMMENTS OF THE COMMERCIAL SMALLSAT SPECTRUM MANAGEMENT ASSOCIATION

Jonathan Rosenblatt
President
CSSMA
575 Florida Street, Suite 150
San Francisco, CA 94110
(628) 221-5324

July 9, 2018

TABLE OF CONTENTS

Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
	)	
Streamlining Licensing Procedures for Small Satellites	)	IB Docket No. 18-86
	)	

COMMENTS OF
THE COMMERCIAL SMALLSAT SPECTRUM MANAGEMENT ASSOCIATION

I. INTRODUCTION

The Commercial Smallsat Spectrum Management Association ("CSSMA") is pleased to respond to the Notice of Proposed Rulemaking in the above-captioned docket.[1] CSSMA is one of the largest associations, with thirty-one members from eleven countries, in the satellite industry. Its membership includes many of the leading operators, ground station service providers, manufacturing and component providers, and other service providers in the small satellite industry. CSSMA seeks to create the conditions for a coordinated, transparent, and expedited spectrum coordination process among commercial small satellite spectrum users, government users, and other satellite and terrestrial users, and to advocate and represent the members' views on spectrum management and other policy matters that affect the small satellite community.

CSSMA's membership has extensive experience with the challenges in obtaining a Part 25 regular commercial authorization for non-geostationary orbit ("NGSO") systems with four of

[1] *See generally Streamlining Licensing Procedures for Small Satellites*, IB Docket No. 18-86, Notice of Proposed Rulemaking, FCC 18-44 (rel. Apr. 17, 2018) ("*Smallsat NPRM*").

its members either in process or with granted authorizations.[2] In addition, its membership has significant experience obtaining experimental licenses under Part 5 or amateur service authorizations under Part 97.[3] Many of its members are foreign companies with experience in foreign licensing processes. As such, CSSMA is particularly well suited to assist the Federal Communications Commission ("Commission") in achieving its stated objective of "develop[ing] an alternative arrangement for authorizing small satellites that is more efficient for both applicants and the Commission and that better reflects the unique nature of small satellite deployment than the existing authorization regimes."[4]

Below CSSMA provides comments to many of the Commission's questions and proposals for a streamlined process under Part 25 for small satellites (the "Streamlined Process") with the hope that Commission can help create a cost effective, transparent, and expedited licensing process for small satellites that allows the United States to continue to lead in innovation in this sector.

II. EXECUTIVE SUMMARY

CSSMA believes that through the *Smallsat NPRM* the Commission is taking a much-needed step toward creating a United States licensing framework that is flexible enough to accommodate the unique nature of this innovative segment of the industry and encourage

---

[2] *See, e.g.*, Stamp Grant, Spire Global, Inc., File No. SAT-AMD-20161114-00107 (granted in part and deferred in part July 13, 2017); Stamp Grant, Astro Digital U.S., Inc., File No. SAT-LOA-20170508-00071 (granted and deferred in part Apr. 12, 2018); Stamp Grant, Planet Labs Inc., File No. SAT-MOD-20150802-00053 (granted Sept. 15, 2016); Petition for Declaratory Ruling, Kepler Communications Inc., File No. SAT-PDR-20161115-00114 (filed Nov. 15, 2016).

[3] *See, e.g.*, Experimental Grant, Spire Global, Inc., File No. 0129-EX-ML-2015 (effective July 17, 2015); Experimental Grant, Planet Labs Inc., File No. 0028-EX-RR-2015 (effective Apr. 01, 2015); Astro Digital U.S., Inc., File No. 0286-EX-CR-2018 (effective May 1, 2018); Experimental Grant, Analytical Space, File No. 0044-EX-ST-2017 (effective June 1, 2018); Experimental Grant, HawkEye 360, Inc., File No. 0024-EX-CN-2017 (effective Feb. 12, 2018).

[4] *Smallsat NPRM* ¶ 21.

companies to continue to seek licenses from the United States. While CSSMA agrees with many of the Commission's proposals, CSSMA would like to highlight that a number of qualifications and requirements the Commission proposes likely would result in creating a process that does not serve these valuable purposes and runs a very real risk of creating a process that is used by very few companies.

In Section III.A.1.b., CSSMA proposes that total orbital lifetime should not be a requirement for the Streamlined Process so long as the satellite meets existing Part 25 orbital debris requirements. Creating new and significantly restrictive orbital debris limits on only one class of license will encourage applicants to use other license types, including foreign licenses, and conflates the purpose of this proceeding with general concerns about existing orbital debris requirements. Any new orbital debris requirements should be discussed in a separate proceeding applicable to all operators and license types. For similar reasons, the Commission should be mindful of actions it takes in application proceedings, which could effectively establish, without notice and comment, informal requirements singling out small satellite operators.[5]

If the Commission adopts an orbital lifetime standard as a requirement for streamlined processing, it should be one that leaves sufficient commercially practicable launches available and also comes with an ability to be met by any "capability to de-orbit," which will accommodate technological development of passive deorbit devices, not just propulsion.

[5] *See, e.g.*, Letter from Henry Goldberg *et al.*, Counsel for Spaceflight, Inc., to Marlene H. Dortch, Secretary, FCC, File No. SAT-STA-20180523-00042 (May 23, 2018) (providing a launch manifest at the request of the International Bureau); Letter from Tony Lin, Counsel for Planet Labs Inc., to Marlene H. Dortch, Secretary, FCC, File No. SAT-MOD-20150802-00053 *et al.*, (July 26, 2016)(submitting a Monte Carlo simulation, using 18 million sample pairs that required more than forty-five days of computation time, to demonstrate a low collision probability risk); Letter from Jenny Barna, Launch Manager, Spire Global, Inc., to Marlene H. Dortch, Secretary, FCC, File No. SAT-LOA-20151123-00078 (Aug. 19, 2016) (submitting a summary of the requirements imposed by the National Aeronautics and Space Administration ("NASA")/International Space Station ("ISS") program director regarding the re-deployment of small satellites from the ISS).

In Section III.A.1.c., CSSMA proposes that a license term of five years from a satellite being placed into its authorized orbit is too short a period to allow the kind of technological development that the Streamlined Process would be most well suited for.

In Section III.A.1.d., while CSSMA agrees that end-of-life replenishment is not appropriate, it believes that an outright prohibition on license extensions and replacement satellites limits the Commission's flexibility and makes a license through the Streamlined Process more expensive and risky when factoring in launch failure, launch delay, and launch-induced anomalies, all of which are beyond the applicant's control. The Commission should have flexibility to allow for replacement satellites and license extensions in these cases.

In Section III.A.1.g., CSSMA strongly disagrees with requirements that satellites licensed through the Streamlined Process either be deployed at or below the ISS or have propulsion as this severely restricts the orbits available to those that are not commercially viable for many operators or requires them to use solutions that are not yet readily available. Imposing this condition could render the Streamlined Process unusable.

In Section III.A.1.j., CSSMA proposes that the requirement for zero re-entry casualty risk is overly conservative and effectively mandates the use of materials that burn up fully on re-entry and precludes a variety of missions that may have a scientific need for different materials or components while presenting infinitesimal (but not zero) re-entry risk. A policy decision that satellites should have zero re-entry casualty risk is not specific to small satellite operations, and to the extent this is a goal of the Commission, it should be discussed in a separate rulemaking proceeding applicable to all operators and license types.

In Section III.A.2, CSSMA agrees on the benefits of a public notice and comment period, but it believes that a typical Part 25 public notice and comment period is not consistent with the

Commission's goal of a more efficient process. CSSMA proposes that the public notice and comment period be limited in scope to the question of whether the applicant meets the requirements to use the Streamlined Process, that the period of comment be limited to fifteen days, and that the Commission be required to dispose of any comments or petitions to deny within forty-five days of their filing. Even more importantly, CSSMA proposes that the Commission start the process of coordination between applicants and Federal agencies via the National Telecommunications and Information Administration ("NTIA") prior to an application being placed on public notice and the two periods progress concurrently.

In Section III.A.4.c., CSSMA proposes that the bond requirement should not apply to the Streamlined Process. Such a requirement unduly burdens operators that are in the initial phases of demonstrating commercial viability. The allocation of spectrum on a non-exclusive, non-first-come, first-served basis through the Streamlined Process is sufficient to mitigate any spectrum warehousing concerns and to deter speculative satellite applications.

In Section III.B.1.a., d., and e., CSSMA provides radio frequency characteristics of small satellite systems and information on their spectrum needs based on our actual experience of its members for the Commission to review to help inform this rulemaking.

In Section III.B.1.b. and g., CSSMA proposes that applicants should not be required to make additional demonstrations, either for all bands or for specific bands, about their ability to share with non-satellites services and should be bound by the footnotes, technical rules, and sharing criteria applicable to the given band being considered and accorded the same rights in such bands as other users in their class and nature of service.

In Section III.B.1.f., CSSMA proposes that inter-satellite links and optical links are not sufficient in and of themselves to serve small satellite spectrum needs but could prove important to certain types of small satellite missions.

In Section III.B.2., CSSMA proposes, based on the experience of its members with their own applications, a number of solutions that would help make coordination between commercial applicants and Federal agencies more timely, efficient, and effective for all parties.

In Section III.C., CSSMA demonstrates the feasibility of small satellites meeting the current requirements of, and sharing with existing users and other small satellites applicants in, several of the specific frequency bands noted by the Commission in the *Smallsat NPRM*.

In Section III.D., CSSMA suggests additional frequency bands that the Commission should evaluate for access by small satellites.

III. DISCUSSION

A. Streamlined Process for Small Satellites

1. Characteristics of a Satellite or System Qualifying for Streamlined Process

a) Number of Spacecraft

The Commission proposes limiting the number of satellites under the Streamlined Process to ten and seeks comment on this number.[6] CSSMA believes the maximum number of satellites under the Streamlined Process should serve at least two purposes. First, for constellations of many satellites, it should be a number sufficient to demonstrate commercial viability prior to the large investment required in a full Part 25 license for the constellation.

[6] *See Smallsat NPRM.* ¶ 27.

Second, for small systems that would be cost prohibitive under Part 25, it should be a number sufficient, either across one or a few licenses, to operate such a system. Based on the experience of its members, CSSMA believes ten satellites is sufficient to serve those purposes.

In addition, the Commission proposes a filing fee of $30,000 for a license under the Streamlined Process.[7] CSSMA understands that the Commission must recover its costs to process these applications and that a $30,000 fee would likely do so.[8] CSSMA believes that a limit of ten satellites per license, when paired with the Commission's suggested fee of $30,000 (which equates to as low as $3,000 per satellite), is a reasonable fee for small innovative companies to pay to license their satellites out of the United States. CSSMA supports adoption of this fee for the Streamlined Process. A caveat is that this fee is only reasonable so long as companies are still able to avail themselves of the Part 5 experimental process for non-commercial and/or technology demonstration satellites.

The Commission also seeks comment on whether it is necessary to adopt limits on the number of applications that can be filed under the Streamlined Process by any individual small satellite operator and its affiliates.[9] CSSMA does not believe such a limitation would serve the public interest. While ten satellites might be sufficient for one operator, it may not be sufficient for all operators that are developing their technology while engaging commercially with customers. In addition, CSSMA has members that build and/or operate satellites for others and might seek several licenses, one for each system, under the Streamlined Process.

If the Commission's concerns are to avoid disincentivizing applications for full Part 25 licenses, this could be better handled by providing an easy transition from a Streamlined Process

[7] *See id.* ¶ 76.
[8] *See id.* ¶ 27.
[9] *See id.*

license to a full Part 25 license or imposing conditions on the Streamlined Process license as to spectrum rights as discussed in Sections III.B-C below. In addition, at $30,000 per license (without ability to replenish those satellites), the fees are still substantial for a Streamlined Process license and, after a certain number of satellites, cost prohibitive as compared to a full Part 25 license application, which has a 15-year term.[10] CSSMA sees no benefit to capping the number of licenses that one operator can obtain under the Streamlined Process.

b) Planned On-Orbit Lifetime

The Commission proposes that an applicant must certify that the total on-orbit lifetime "is planned to be five years or less, including the time it takes for the satellite(s) to deorbit."[11] For the reasons below, CSSMA proposes that total orbital lifetime should not be a requirement for the Streamlined Process so long as the satellite meets existing Part 25 orbital debris requirements.[12] Should those requirements change for all operators and license types, then they would apply to the Streamlined Process as well. The Commission has other requirements (such as probability of collision) that are better suited to meet orbital debris concerns without unduly restricting the orbits (and thus launch availability) of small satellite operators and making the Streamlined Process of very limited utility to commercial operators.

CSSMA would like to first point out that limits on on-orbit lifetime effectively limit the orbits accessible by a small satellite and thus launch opportunities. Small satellites typically access low Earth orbit ("LEO") as secondary customers. As such, they do not have control over

---

[10] If each satellite has a lifetime of three years and no replenishment, each satellite would have to be replaced five times to match a Part 25 license term, costing $150,000 per license. As the Commission proposes that licenses be limited to ten satellites each, at a constellation sized at roughly thirty satellites there becomes a strong economic incentive to switch to a Part 25 license.
[11] *See Smallsat NPRM* ¶ 28.
[12] *See generally* 47 CFR § 25.114(d)(14).

their launch parameters and time and date of launch, highly restricting their launch opportunities. The single biggest risk to small satellite business models currently is launch availability and launch schedule delays. Using NASA's Debris Assessment Software ("DAS"), CSSMA has analyzed the orbits that a satellite would be restricted to by the total on-orbit lifetime requirement proposed by the Commission. Using an area-to-mass ratio of three current Part 25 nanosatellite operators Planet Labs Inc., Astro Digital US, Inc. ("Astro Digital"), and Spire Global, Inc., a five-year license orbital lifetime would limit a satellite to an orbit 500 km,[13] 520 km,[14] and 590 km[15] respectively.

Based on this orbital limitation, CSSMA finds that fifty percent of non-ISS launch opportunities over the last five years would have been inaccessible to these operators had they been using the Streamlined Process for their early technological development. The restricted set of launch opportunities available under the Streamlined Process would be a significant deterrent to using such process for these types of operators.

CSSMA is unsure whether the Commission proposes that it be each satellite or all satellites covered by a license under the Streamlined Process must exit orbit within five years. The latter approach will further limit the utility of a license under the Streamlined Process. For instance, assuming a small satellite company was booked on three launches spaced six months apart and with one launch delay of six months, the third satellite would be limited to an orbital lifetime of just three years. This would limit that third deployment to an ISS deployment, eliminating all non-ISS launch opportunities for the third deployment.

[13] Analysis is run in NASA DAS for 0.0066 m^2/kg area-to-mass ratio and 2018 launch date/solar cycle.
[14] Analysis is run in NASA DAS for 0.0123 m^2/kg area-to-mass ratio and 2018 launch date/solar cycle.
[15] Analysis is run in NASA DAS for 0.029 m^2/kg area-to-mass ratio and 2018 launch date/solar cycle.

With respect to ISS deployments, CSSMA notes that if the Commission does not allow any satellites under the Streamlined Process to go above the ISS, the likelihood of such process being used at all is extensively diminished. The orbits of 400 km and below are not commercially viable in all solar cycles because many small satellites will de-orbit well within their operational lifetimes. As an example, for the three area-to-mass ratios stated above, orbital lifetime at 400 km is 2.9,[16] 0.29,[17] and 0.12[18] years respectively. If one of the requirements of the Streamlined Process is in effect that a satellite can only be used for a small fraction of its operational lifetime, CSSMA believes few commercial actors would pursue such a license as the costs of lost operational life would make the process cost prohibitive. There is already an experimental process under Part 5 for very short duration experimental or technology demonstration missions, and there is no need to create a duplicative process under Part 25 that is not commercially practicable.

If an orbital lifetime must be adopted for the Streamlined Process that is different than Part 25, it should be one that leaves sufficient commercially practicable launches available to users of such process.

The Commission also seeks comment as to whether a small satellite that is not designed with a sufficiently short orbital lifespan to result in atmospheric re-entry within five years nevertheless be eligible if it has the capability to maneuver to a lower orbit that would ensure re-entry. CSSMA does not see why such a satellite would not be eligible so long as it meets the overall requirement that the Commission adopts as to orbital lifetime. In addition, "capability to maneuver" strikes us as too narrow and suggests that propulsion rather than passive techniques

[16] Analysis is run in NASA DAS for 0.0066 m^2/kg area-to-mass ratio and 2018 launch date/solar cycle.
[17] Analysis is run in NASA DAS for 0.0123 m^2/kg area-to-mass ratio at highest drag solar cycle.
[18] Analysis is run in NASA DAS for 0.029 m^2/kg area-to-mass ratio at highest drag solar cycle.

might be necessary.[19] Therefore, CSSMA believes that if an orbital lifetime standard is adopted, it should come with an ability to be met by any "capability to de-orbit," which will accommodate technological development of passive deorbit devices.[20]

c) License Term

The Commission proposes a license term for satellites of five years and that the license term would "begin once one satellite has been placed into its authorized orbit."[21] CSSMA believes the period is too short and proposes that the Commission adopts a license term that (i) begins not on placement into authorized orbit but upon certification by the operator of a satellite successfully commencing operations in orbit and (ii) requires that all satellites under the license be launched within two years of the commencement of operations in orbit of the first satellite under the license. As with Part 25, CSSMA does not believe the license term should be tied to orbital lifetime; however, the Commission should consider orbital lifetime requirements separately in whether the license should be granted.

While, as the Commission notes,[22] a typical operational lifetime of *one* nanosatellite is between one and three years, CSSMA believes a principal use of the Streamlined Process is for technology development on the way to a full Part 25 license. Technology development requires some amount of launching, learning, and iterating across more than one deployment. This process takes time and requires the operational lifetime of multiple versions of small satellites. Based on the experience of CSSMA members, such process takes one to three years of focused

---

[19] *See Smallsat NPRM* ¶ 28.
[20] *See Technical Education Satellite Series: TechEdSat-5 Technologies for Passive Re-entry, Future Sample Return and Mars Missions*, NASA, https://www.nasa.gov/sites/default/files/atoms/files/techedsat5-factsheet-508-april2017.pdf (last visited June 4, 2018).
[21] *Smallsat NPRM* ¶ 29.
[22] *See Smallsat NPRM* ¶ 28.

small deployments. A license term of five years from first launch (even if it does not include the entire orbital lifetime) is far too limiting. A license term of five years that requires the entire orbital lifetime to occur during the license term would be commercially unusable for more than one deployment taking into account CSSMA members' experience with historic launch delays. While an operator could obtain a license for each deployment, this maneuver would increase the cost of these small deployments and increase the burden on the Commission and applicant in obtaining licenses, which will not further the public interest.

In terms of the start of the license clock, CSSMA proposes that license term should commence upon bringing into use the authorized frequencies, consistent with international norms,[23] and not when a satellite is "placed into its authorized orbit" as proposed in the *Smallsat NPRM*. The Commission's formulation is potentially problematic as it would start the clock even upon deployment of satellites rendered nonfunctional by launch anomalies as was the case in a recent Soyuz launch in 2017.[24]

The Commission has asked whether the license term should begin at time of grant.[25] CSSMA would discourage using the date of license grant to start the license term clock. That would make the entire license subject to launch delays of the first launch. While the development cycles of small satellites are faster than historic satellite busses, small satellites are often launched as secondary payloads and are often subject to launch delays (sometimes significant ones). It is not infrequent that secondary payloads are even bumped between launch vehicles, changing launch dates and orbits. In the event that a license cannot be extended as proposed by the Commission, this prohibition could highly disincentivize use of the Streamlined

[23] *See* ITU Radio Regulations, Article 11 (2016).
[24] *See, e.g.*, Debra Werner, *Mysteries surrounding July 14 Soyuz flight solved?*, SpaceNews (Mar. 12, 2018), http://spacenews.com/mysteries-surrounding-july-14-soyuz-flight-solved-not-quite/.
[25] *See Smallsat NPRM* ¶ 29.

Process or, even worse, incentivize license applications being filed later after launch dates become firmer, potentially resulting in unnecessary requests for expedited licenses and potentially missed launches.

d) License Extension and Replacement Satellites

CSSMA agrees that replenishment satellites, as part of planned end-of-life replenishment, are not necessary under the Streamlined Process, which it sees as a process for early-stage development.[26] The inability to replenish is one of the key factors that will cause large scale commercial systems to be filed under regular Part 25, which CSSMA feels is appropriate. However, as demonstrated with the experience of Astro Digital and with other CSSMA members, small satellite operators are often subject to launch failures (including launch failures that cause on-orbit anomalies) through no fault of the respective small satellite operator. Launches can also be completely rescheduled at the request of the primary payload (customer) of the launch provider. Secondary customers, universally, have no say in any rescheduling activities. CSSMA believes replacement satellites for the original licensed satellites should be allowed in these contexts to achieve the objective of allowing an operator to fully benefit from their license under the Streamlined Process.

CSSMA also believes that the Commission should retain flexibility to provide for license extensions. As discussed above, a number of circumstances could result in an operator not being able to launch and operate its satellites within its license term. In addition, operators may find they get longer operational lifetime out of their satellites than predicted by the official design life, decreasing expenses, improving service quality, and reducing service costs. The public

[26] *See id.* ¶ 30.

interest (in facilitating the innovation and promise of small satellites, improvement in service quality, and reduction in service costs) is undermined by forcing operators to shut down operational satellites that happen to exceed their design life.

e) Applicability to Other Types of Missions

The Commission also requests comments on the potential applicability of the proposed Streamlined Process for commercial lunar missions (or other commercial missions beyond Earth's orbit).[27]

CSSMA supports the idea of allowing companies planning missions to the Moon and beyond to take advantage of the Streamlined Process. Although not all such missions would be applicable for this Streamlined Process, CSSMA does not believe it serves the public interest to exclude all commercial missions beyond Earth orbit from this proposed process.

As noted in the *Smallsat NPRM*, missions beyond Earth orbit would probably need different standards for license terms and disposal. CSSMA agrees with the Commission's suggestion to base license terms on the anticipated operation lifetime of such missions.[28]

The Commission may want to consider relaxing its proposed maximum mass requirement of 180 kg for such missions as spacecraft designed for lunar missions (particularly those going to the surface) will often have more mass than a typical LEO small satellite. At the very least, clarifying that the Commission will only count the "dry" (without fuel) mass of a spacecraft going beyond Earth orbit would be helpful since many potential commercial lunar spacecraft (*e.g.*, Moon Express[29]), unlike most LEO small satellites, include built-in upper-stage engines to

[27] *See id.* ¶ 31.
[28] *See id.*
[29] *See MX-1 Scout Class Explorer*, Moon Express, http://www.moonexpress.com/robotic-explorers/mx-1-scout-class-explorer/ (last visited June 11, 2018).

get the vehicle from Earth orbit to the final destination and need to be heavier than a typical small satellite to survive a more rugged space environment. CSSMA proposes raising the maximum mass requirement to 500 kg for spacecraft going beyond Earth orbit.

If the Commission does extend the use of the proposed Streamlined Process to missions beyond earth orbit, it should consider using the term "spacecraft" (already defined in 47 CFR § 25.103) or "small spacecraft" instead of or in addition to "small satellite" in its rules as many potential missions beyond Earth will intend to land on, or travel between, celestial bodies such as the Moon and Mars rather than orbit them.

f) Maximum Spacecraft Size

The Commission proposes a maximum mass of 180 kg per satellite as a requirement to use the Streamlined Process.[30] CSSMA agrees that this upper threshold is sufficient to encompass a variety of Earth-orbiting spacecraft and includes flexibility to accommodate evolving design and technologies for small satellites. However, whether the 180 kg limit is the correct one is unclear to us. The Commission should also consider 225 kg (the maximum payload mass for a Rocket Lab launch),[31] 200 kg (maximum medium class small satellite mass referenced by Aerospace Corporation),[32] and 500 kg (the maximum payload mass for a Virgin Orbit launch).[33]

---

[30] *See Smallsat NPRM* ¶ 32.
[31] *See Electron*, Rocket Lab USA, https://www.rocketlabusa.com/electron/ (last visited June 18, 2018).
[32] *See* Carrie O'Quinn and Danielle Piskorz, *Setting the Standard: Launch Units for the Smallsat Era*, The Aerospace Corporation, http://aerospace.wpengine.netdna-cdn.com/wp-content/uploads/2018/06/Piskorz-OQuinn_StdLaunchUnits_05252018.pdf (last visited June 18, 2018).
[33] *See LauncherOne*, Virgin Orbit, https://static1.squarespace.com/static/5915eeab9de4bb10e36a9eac/t/5a5fcb70ec212d98c9f51374/1516227453251/180117_service-guide_reference.pdf (last visited June 18, 2018).

g) Deployment Orbit and Maneuverability

The Commission proposes that applicants under the Streamlined Process would certify that their proposed satellites will comply with one of several options, including (i) certifying that the satellite will be deployed at an orbit below the ISS or (ii) certifying that the satellite will be deployed from the ISS itself or from a vehicle docked with the ISS.[34] CSSMA supports these proposals.

The Commission further proposes that for any satellite deployed above the ISS or that crosses its orbit (which is every LEO satellite, including all foreign-licensed satellites, above 400 km), the operator would need to certify that the satellite has sufficient propulsion capabilities to perform collision avoidance maneuvers and deorbit within the required license term.[35] CSSMA disagrees with this standard as far too narrow. CSSMA proposes that the requirement the Commission adopts be that the applicant demonstrate a method of collision avoidance that is sufficiently reliable to meet any then existing requirements of the ISS program with respect to small satellites that cross the ISS orbit.

For the reasons set forth above, limiting the Streamlined Process only to below ISS deployments makes the Streamlined Process of little value to many commercial applicants. Both the ISS program requirements and the technologies available to meet them will change over time. While CSSMA agrees that new and exciting technologies, including in the area of small satellite propulsion, are constantly developing, it disagrees that some types of these new technologies would be easier for the Commission to review than others. Both would require detailed Commission review at the outset, and over time, as a technology became more common,

[34] *See Smallsat NPRM* ¶ 33.
[35] *See id.* ¶ 34.

it would be easier for the Commission to review. CSSMA believes that the Commission should not adopt rules requiring propulsion or other technology to be used above the ISS (and not limit Streamlined Process licenses to at or below the ISS) but rather approve applications on a case-by-case basis and work with industry and the ISS program as technology develops to determine what technology, if any, should be required for satellites deployed above the ISS.

h) Operational Debris and Collision Risk

The Commission proposes that the Streamlined Process be limited to satellites that release no operational debris during their mission lifetime and that applicants be required to certify as much as part of their application.[36] The Commission also proposes to retain the requirement from Part 25 that applicants must also include a statement that the satellite operator has assessed and limited the probability of accidental explosions.[37] Finally, the Commission proposes that applicants certify that the probability of each satellite's risk of collision with large objects is less than 0.001.[38] CSSMA agrees that these are important requirements for all satellite operators, including those which obtain licenses through the Streamlined Process, to meet.

Responding to the Commission's questions seeking comment as to whether a certification is sufficient and what if any additional information should be provided, CSSMA believes that all operators should provide the same information on these important matters. Moreover, it believes that an Orbital Debris and Assessment Report ("ODAR"), prepared in a manner consistent with existing Part 25 rules, would be appropriate. Preparation of an ODAR is not a significant burden to a satellite operator and provides all other operators and the Commission with detailed analysis of how the foregoing requirements are met. In fact, free software such as NASA DAS is

[36] *See id.* ¶ 35.
[37] *See id.* ¶ 36.
[38] *See id.* ¶ 37.

available to assist with such analysis. Such detailed analysis, subject to Commission and peer review, is a critical element of ensuring the orbital debris mitigation guidelines are met.

The Commission asks specifically whether the 0.001 threshold is necessary given the other proposed criteria for the Streamlined Process, such as limiting orbital altitude or requiring propulsive capability.[39] In fact, CSSMA believes the Commission should adopt the 0.001 threshold in lieu of limiting the orbital altitude or requiring propulsive capability and not in addition to those requirements for the reasons set forth above.

i) Trackability

The Commission proposes as a requirement that an applicant certify its satellites will be no smaller than 10 cm x 10 cm x 10 cm, the size of a 1U cubesat to ensure that objects can be tracked.[40] CSSMA believes that this limit would not overly restrict the number of applicants eligible for the Streamlined Process but again urges the Commission to adopt a more flexible approach. CSSMA urges the Commission to allow for an operator, which cannot meet the minimum size standard, to certify and show that its satellite can be tracked reliably by widely-available tracking technology.

Over the years, it is likely that Space Situational Awareness capabilities improve whereas regulations by their nature are time consuming to change. It may be the case that reflector or transponder technology cited by the Commission or other technologies become obviously capable of tracking a smaller than 1U cubesat bus within a few short years or sooner. In that event, those operators would be barred from the Streamlined Process without a further rulemaking, which could take years.

---

[39] *See id.*
[40] *See id.* ¶ 38.

The Commission further proposes that each satellite under the Streamlined Process contains a unique telemetry marker allowing it to be readily distinguished from other satellites or space objects.[41] CSSMA suggests the Commission provide further clarification as to how these telemetry markers are required to work. If they were merely a few bits of information in a satellite's telemetry it would perhaps not be an undue burden, but it is not clear to CSSMA as to what interest is served by being able to distinguish between satellites licensed under the Streamlined Process and all other space objects, including those licensed under the experimental process, the amateur process, foreign process, etc.; none of those licensed satellites are distinguishable amongst each other by any unique telemetry markers. CSSMA also believes that the standard Part 25 process of notifying the Commission of a deployment and insertion orbit allows satellites to be accurately tracked to a license, streamlined or otherwise. CSSMA believes there is an alternative requirement that could be imposed, which would provide an additional means of continually updating the orbit of any and all space systems licensed by any administration, including the Commission. If the Commission were to require that all satellites associated with any space station licensee had to be registered along with their (once vetted) International Designator, as it appears in all Joint Space Operations Center ("JSpOC") two-line element sets ("TLEs"), with the Commission, then an object and its orbit would be locked together permanently.[42]

[41] *See id.*

[42] This information is contained in columns ten through seventeen of an orbital object's TLE message and would tie a particular satellite to its current orbital elements precisely. When satellites are first launched the TLEs between satellites on the same launch are frequently confused until sorted out by JSpOC and the community of satellites on any one launch vehicle. Once established, the International Designators never change and are accurate until the object re-enters the atmosphere, allowing any satellite's orbital elements to be reassessed multiple times per day if necessary.

j) Casualty Risk

The Commission proposes that applicants under the Streamlined Process certify that they conduct a casualty risk assessment using NASA DAS or other high-fidelity model and that the assessment resulted in human casualty risk of zero.[43] CSSMA believes this proposal is too strict. The current risk standard for human casualty upon re-entry is 1:10,000. While small satellites have much smaller mass, re-entry risk is not driven solely by mass, but it is also driven by materials used for the satellite bus and components. Nothing is ever zero although NASA DAS and other programs will eventually round down to zero at the fifth or sixth decimal place. CSSMA urges the adoption of the same standard that would apply to all other operators unless and until such standard is changed for all operators in a separate orbital debris proceeding.

As with collision risk above, CSSMA believes that applicants should prepare an ODAR showing their analysis in how they arrived at whatever casualty risk standard the Commission determines to adopt.

k) Cessation of Emissions

Finally, the Commission proposes that applicants certify that satellites have the ability to receive command signals and cease transmissions as a result of command.[44] Again, CSSMA believes it is better to dictate ends rather than means and believes existing Section 25.207 of the Commission's rules, and cited by the Commission,[45] already provides a more flexible standard that achieves the same end: "[s]pace stations shall be made capable of ceasing radio emissions by the use of appropriate devices (battery life, timing devices, ground command, etc.) that will

---

[43] *See Smallsat NPRM* ¶ 39.
[44] *See id.* ¶ 40.
[45] *See id.*

ensure definite cessation of emissions."[46] CSSMA believes there are numerous ways, some more reliable than telecommand, to cause cessation of emissions. For instance, software onboard a satellite can be programmed to cease emissions if and when a ground contact has not been established for a certain period of time. This alternative would ensure cessation of emissions even if there was an anomaly with the receive antenna or radio on the satellite. In addition, a number of satellites may not have continuous radio emissions but may only operate after receiving telecommands from a ground station. For such satellites, there would be no need to show that a satellite can cease transmissions as a result of a command. Therefore, CSSMA believes the better approach is to require applicants in the Streamlined Process to certify that they meet the requirements of Section 25.207 and provide analysis as to how they do so.

2. Small Satellite Application Processing

The Commission proposes that applicants under the Streamlined Process must be exempt from a processing round and required to (a) certify that operations of their satellite will not interfere with those of existing operators, (b) certify that it will not unreasonably preclude future operators from utilizing the assigned frequency band(s), and (c) provide a brief narrative description illustrating the methods by which future operators will not be unreasonably precluded.[47] CSSMA agrees with this proposal. Frequency usage that is exclusive and/or precludes future uses is not appropriate for the Streamlined Process as it requires further analysis and potentially processing rounds, which are certainly not streamlined.

---

[46] 47 CFR § 25.207.
[47] *See Smallsat NPRM* ¶ 43.

The Commission also proposes that in bands where Part 25 licenses are authorized pursuant to a processing round the Commission "anticipates that small satellites authorized on a streamlined basis would be subject to some limitations on a frequency-band specific basis, including, if appropriate, non-interference, non-protected with respect to the Part 25 systems."[48] CSSMA agrees with this approach; such small satellites that were not part of a processing round would be subject to a lower level of spectrum rights compared to satellites that had been through a processing round.

The Commission further tentatively concludes that full-time Fixed-Satellite Service ("FSS") and Mobile-Satellite Service ("MSS") and other operations requiring full time un-interrupted availability of assigned spectrum would not be appropriate for the Streamlined Process but that non-full-time FSS and MSS operations could qualify for the Streamlined Process if the criteria above are met.[49] CSSMA agrees.

3. Public Notice

The Commission indicates that the Streamlined Process would be subject to public notice under Part 25.[50] CSSMA notes that a number of applications, such as for experimentals, are not subject to public notice and comment periods. CSSMA believes that the Streamlined Process has elements that require some form of public notice and comment but that full notice and comment could defeat many of the purposes of streamlining. CSSMA suggests limiting the nature of comments that may be made in the Streamlined Process only to those that challenge the qualifications of the operator to use such process. Additionally, the public notice period for the Streamlined Process could be shortened to fifteen days. Finally, an overall period of forty-five

[48] *Id.* ¶ 44.
[49] *See id.* ¶ 45.
[50] *See id.* ¶ 45 n.141.

days from the end of the public notice period for a decision deadline could be instituted where comments made during public notice must be resolved between the operators; in lieu of such an agreement, the Commission must act to dismiss the application or dismiss the petition to deny.

In addition, one of the longest periods of time to obtain a Part 25 operating license is coordination with Federal agencies via NTIA. CSSMA suggests that this process be started as soon as possible, at least concurrently with an application being placed on public notice, allowing at least 30 extra days for coordination between applicants and Federal agencies via NTIA. It is important that a more standardized way for industry to work with the involved Federal Agencies needs to be found in the longer term. Otherwise, it is likely that the Streamlined Process will become dwarfed by coordination time with the government.

4. Application Requirements

a) Schedule S and Form 312

The Commission proposes that Form 312 and Schedule S continue to serve as basis of applications in the Streamlined Process.[51] CSSMA believes that Form 312 is fairly straightforward and easy for smallsat companies to complete; however, it encourages the Commission to not require Streamlined Process applicants to submit specific orbital deployment parameters and antenna gain contour plots in the Schedule S. For example, orbital plane related information for satellites without station keeping may not be known at time of application submission due to the everchanging and opportunistic nature of the secondary launch market, which most, if not all, Streamlined Process applicants will use to launch their satellites. This same information may also not be useful or current soon after deployment of satellites without

[51] *See id*. ¶ 47.

station keeping as the deployment inclination angle will not change but the deployment altitude will lower over time, changing the orbital period for these satellites. Also, antenna gain contour plots are dependent on orbital altitude, so they are unnecessary and quite burdensome to submit for each antenna and every possible orbital altitude. Instead, in the narrative, Streamlined Process applicants can simply provide a range of the deployment altitudes/inclinations (applicable to only applicants without station-keeping ability on board their satellites) and a worst-case representative antenna gain contour plot for each antenna (applicable to all applicants), which provides all the information necessary to run orbital debris and radiofrequency interference analyses.

b) Narrative

The Commission further proposes that the narrative section of Part 25 applications be replaced by the various certifications required in the qualifying criteria and some information in narrative form as to how they meet the qualifying criteria.[52] CSSMA reiterates that some analysis backing up the certifications, potentially in the form of a streamlined ODAR report, should be required. This type of submission would allow the Commission and other operators to review the assumptions and analysis, particularly around collision risk, casualty risk, and other orbital debris matters, that goes into the certifications.

c) Revised Bond Requirement

The Commission proposes to maintain the bonding requirement for the Streamlined Process but provide a one-year grace period, beginning 30 days after license grant, during which small satellites would not have to post bond.[53] CSSMA proposes that the bonding requirement

[52] *See id.* ¶ 48.
[53] *See id.* ¶¶ 49-53.

be completely eliminated from the Streamlined Process as it does not serve its intended purpose.[54] Specifically, assuming the Commission adopts certain of the other proposals regarding processing rounds and spectrum priority,[55] it would seem that spectrum warehousing is not implicated by the Streamlined Process as spectrum remains available to all on a non-exclusive, non-first come, first-served basis. In addition, the $30,000 application fee and numerous restrictions and qualifications imposed on applicants, when combined with the inability to use the Streamlined Process for spectrum warehousing, would seem to deter speculative satellite applications.

While the postponement of the bonding requirement for one year would afford many small satellite operators the ability to launch a satellite within the one-year period, it is unclear to CSSMA whether they would launch fifty percent of the maximum number of satellites authorized under their licenses. While the Commission proposes that the bond requirement could be avoided if the failure to meet the milestone requirements was due to launch delays, its approach of requiring surrender of the license may impose a significant burden on small innovative companies who have spent the time and money to obtain a license and are delayed in launching through no fault of their own. More generally, the process of requesting waivers of bonding requirements on a case-by-case basis creates burden on the Commission and the licensee and could create significant inefficiencies in the Streamlined Process.[56]

---

[54] *See, e.g.*, *Comprehensive Review of Licensing and Operating Rules for Satellite Services*, Report and Order, 28 FCC Rcd 12403, 12418 ¶ 40 (2013) ("The milestone requirements, together with a bond requirement also adopted at that time, are designed to discourage speculative applications. They also help ensure that licensees remain committed and able to proceed with timely implementation of licensed space stations[.]").
[55] *See Smallsat NPRM* ¶¶ 41-46.
[56] *See, e.g.*, Letter from Trey Hanbury, Counsel for Spire Global, Inc., to Marlene H. Dortch, Secretary, FCC, File No. SAT-LOA-20151123-00078 (filed Apr. 4, 2016).

For these reasons and because the bond requirement does not seem to serve its intended purpose under the Streamlined Process, CSSMA urges the Commission to eliminate it from the Streamlined Process.

B. Frequency Considerations for Small Satellites

The Commission addressed a number of issues relevant to frequency selection for small satellite systems.[57] Comments are sought regarding the relationship between the proposed Streamlined Process and the particular bands for which the applicant may apply. Further, comments are sought related to sharing with Federal users. And, comments are also sought on several proposals to expand the use of existing satellite allocated bands for small satellite use. The Commission also considers whether some MSS and FSS bands could be allocated for inter-satellite links for small satellites and whether such proposals are appropriate.

As a general matter, CSSMA appreciates the Commission's efforts to find frequencies that might be capable of assignment on an expedited basis. It provides preliminary comments below on many of the Commission's suggestions and other frequencies as well. It stands ready to assist the Commission in trying to review each of these frequencies for appropriateness for a small satellite allocation. However, it is important to note that a frequency that may be useable by one type of small satellite (say a 6U cubesat) may not be suitable for another type of small satellite (say a 1U cubesat) due to differences in size, power, and other factors. So, CSSMA urges the Commission to take the approach of allowing small satellite operators to apply via the Streamlined Process for any frequency band that matches their category of service and, while at

[57] *See Smallsat NPRM* ¶¶ 55-73.

the same time, try to find certain frequency allocations to add to the United States Table of Frequency Allocations that may benefit small satellites more generally.

1. Scope of Frequency Use

a) Spectrum Use Characteristics of Small Satellites

The Commission requested information regarding the frequency use characteristics of small satellites.[58] CSSMA provides the following information regarding its own internal review, which takes into consideration its members' business plans and experiences. This review (in Table 1) includes its members which are actually operational at this time (several of whom have been issued radio licenses by the Commission)[59] and currently raising capital and have developed detailed plans for their communications needs. Bandwidth and data rates are normalized as per satellite.

Table 1: Small Satellite Spectrum Use Characteristics

Service	Link Category	Characteristics		Earth Station Characteristics
		Data Rate Range	Bandwidth	
Communications (FSS/MSS/ Internet of Things)	Telemetry, tracking, and command ("TT&C")	1-50 kbps	5 -50 kHz	Small yagi or dish
	User service link	1-100 Mbps	1-30 MHz	Very small portable or fixed
	Backhaul link	1-1000 Mbps	1-300 MHz	Small aperture dish

[58] *See id.* ¶¶ 56-59.
[59] *See supra* note 2.

Service	Link Category	Characteristics		Earth Station Characteristics
		Data Rate Range	Bandwidth	
Earth Exploration-Satellite Service (“EESS”)/Imaging (All Ground Sample Distance Resolutions)	TT&C ↑	5-100 kbps	10 kHz-1 MHz	Small yagi or dish
	High speed (“H.S.”) data link ↓	10 Mbps-5 Gbps	5 MHz-1.5 GHz	Small aperture dish (G/T < 30 dB/K)
	Data link (might include telemetry) ↑	0-250 Mbps	0-100 MHz	Small aperture dish (EIRP < 65 dBW)
EESS/Non-Imaging	TT&C	1-50 kbps	5-50 kHz	Small yagi or dish
	Data link ↓	100 kbps-1 Gpbs	50 kHz-500 MHz	Small aperture dish (G/T < 30 dB/K)
	Data link ↑	0-25 Mbps	0-50 MHz	Small aperture dish (EIRP < 65 dBW)
Science/ Commercial Science	TT&C ↑	1-50 kbps	5-50 kHz	Small yagi or dish
	Data link ↓	10 Mbps - 5 Gbps	5 MHz - 1.5 GHz	Small aperture dish
Tomography (low end)	Data link ↑	100 kbps-1 Gpbs	50 kHz-500 MHz	Small aperture dish
Synthetic Aperture Radar (high end)	Sensor link (radiofrequency (“RF”))	N/A	10-600 MHz (typical)	Phased array/horn/ other

To some, the values in Table 1 may appear optimistic or even unrealistic; however, it would be a common mistake to scale the capabilities of small satellites in ratio to their mass and/or volume compared to large spacecraft as has far too often been done. It is perhaps better to think about the miniaturization trends that have been achieved by the computer industry over the past twenty years and apply Moore's Law to satellites as well as solid-state device technology itself. In this same timeframe, mass, power, and volume reduction have occurred simultaneously along with a hardware and software capability explosion. For example, just in the last twelve to eighteen months, (i) specialized digital devices (*e.g.*, Analog to Digital Converters and Digital to Analog Converters) are twice as fast, (ii) RF amplifiers have 3 dB higher power output, and (iii) Gallium nitride Solid State Power Amplifiers devices are 2X more efficient and can work at 2X higher frequencies, which enables the employment of millimeter-wave frequencies (*i.e.*, Ka-band). While this phenomenon was spawned by the mobile phone and personal computer industries, the same changes have also occurred and, just as dramatically, in the aerospace sector. Hence, it is possible today for a single small satellite to deliver more than 1 Gbps to a small, cost-effective station on the ground. If flexible and appropriate rules are adopted in this *Smallsat NPRM*, it will enable very capable space-based systems indeed.

b) Sharing with Other Services

The Commission asks specifically whether small satellite operators should be required to make additional demonstrations, either for all bands or for specific bands, about their ability to share with non-satellites services.[60] CSSMA does not believe any additional showing is necessary beyond being able to meet the footnotes, technical rules, and sharing criteria applicable to the given band being considered. CSSMA believes it is not necessary to create any additional technical rules, such as the ones suggested,[61] specifically applicable to small satellite operations, when International Telecommunication Union ("ITU") Radio Regulations ("RR")

[60] *See id.* ¶ 56.
[61] *See id.*

and Part 25 technical rules as non-small satellite operations are already in place to avoid harmful interference.[62] Creating additional small satellite-specific operational rules goes against the efficiency goals of the Commission in this rulemaking as it would need to review and approve of additional technical analyses on a band-by-band basis when considering a streamlined application. CSSMA include some more detailed discussions on a band-by-band basis in Section III.C.

The Commission seeks further comment on whether small satellites authorized under the streamlined process should be required to protect other services and accept interference from other services in all instances where they are operating in frequency bands that are shared with non-satellite services, or alternatively, seeks comment on whether these small satellites should be afforded interference protection that is consistent with the relevant satellite allocation in a particular frequency band.[63] CSSMA believes that small satellites operating in accordance with the Table of Frequency Allocations should have protection consistent with the Table of Frequency Allocations. For instance, if a small satellite is in a primary service category, CSSMA sees no interest being served by putting in it at a lower level of spectrum priority than another service in a secondary service category. As discussed above, small satellites under the Streamlined Process that are not subject to a processing round should have a lower level of spectrum rights than satellites that have spectrum allocated via a processing round in the same level of priority; however, they should not be placed on a level of no spectrum rights. Giving no spectrum rights would make a small satellite license through the Streamlined Process a precarious foundation on which to build a business. There is no reason that small satellites with

[62] *See, e.g.*, *See* ITU Radio Regulations, Chapters II-III; VI (2016); 47 CFR Part 25 Subparts B-D.
[63] *See Smallsat NPRM* ¶ 56.

a license through the Streamlined Process should not have the spectrum rights accorded to its category of service.

c) Non-Exclusive List of Frequencies

The Commission seeks further comment as to whether it should include a non-exclusive list of frequencies in section 25.202 of the Commission's rules.[64] CSSMA does not believe such a list would be helpful with respect to most frequencies and could be misleading to operators if certain bands have technical requirements or existing users that would make coordination impossible. The Commission and the ITU already have tables of frequency allocations showing satellite operators all available bands for their categories of service(s). Unless the Commission is able to find one or more frequency bands to allocate to small satellites specifically and which can be subject to service rules that would allow for expedited coordination with Federal agencies and other users, CSSMA would not see publication of a list as helpful. Therefore, CSSMA agrees with the Commission's second proposed alternative to consider applications on a case-by-case basis, bearing in mind the relevant frequency allocations.[65]

d) Need to Access Specific Bands

The Commission also asks commenters to address their need to access specific bands.[66] Bearing in mind that essentially any frequency in the ITU Table of Frequency Allocations is allocated to multiple services, and usually on a co-primary basis, CSSMA once again reiterates that small satellite operators qualifying for the Streamlined Process are not seeking special or exclusive privileges in particular bands and only request that the rights given in the bands match

[64] *See id.* ¶ 57.
[65] *See id.*
[66] *See id.*

the applicant's category of service and under the same circumstances as prescribed by the domestic and international tables of frequency allocations including applicable footnotes. There are specific bands (most acknowledged by this *Smallsat NPRM*) currently being used by small satellites that are of strategic importance to the community. These are presented in Table 2.

Table 2: Critical Specific Small Satellite Frequencies and Necessary Bandwidths

Band or Spectral Region	Necessary Bandwidth Range	Utilization (Category of Service)	Link Direction	Satellite Antenna Characteristics
Lower UHF (300-500 MHz)	1-50 kHz	Low latency data uplink Specific sub-band(s) or channels (Space Operation Service ("SOS")/Space Research Service ("SRS") (Command)	Earth-space	Omni-directional ("omni")
Lower UHF (300-500 MHz)	1-50 kHz	Low latency data downlink Specific sub-band(s) or channels (SOS) (Telemetry)	space-Earth	Omni
2025-2110 MHz	50 kHz-5 MHz	Data uplink or command (EESS or SOS/SRS)	Earth-space	Omni or directive antenna
2000-3000 MHz	50 kHz-3 MHz	Data downlink or telemetry (EESS or SOS/SRS)	space-Earth	Omni or directive antenna
8025-8400 MHz	5-350 MHz	H.S. data downlink (EESS)	space-Earth	Directive antenna(s)
10.7-12.7 GHz	1-50 MHz/ frequency division multiplexing ("FDM") (multiple FDMs)	H.S. data downlink (FSS)	space-Earth	Directive antenna(s)

Band or Spectral Region	**Necessary Bandwidth Range**	**Utilization (Category of Service)**	**Link Direction**	**Satellite Antenna Characteristics**
13.75-14.5 GHz	1-50 MHz/FDM (multiple FDMs)	H.S. data uplink (FSS)	Earth-space	Directive antenna(s)
25.5-27.0 GHz	5 MHz-1.5 GHz	H.S. data downlink (EESS)	space-Earth	Directive antenna(s)
28.5-30.0 GHz	1-50 MHz/ FDM (multiple FDMs)	H.S. data uplink (EESS)	Earth-space	Directive antenna(s)
17.8 -19.3 GHz	1-50 MHz/ FDM (multiple FDMs)	H.S. data downlink (FSS)	space-Earth	Directive antenna(s)
27.5-30.0 GHz*	1-50 MHz/ FDM (multiple FDMs)	H.S. data uplink (FSS)	Earth-space	Directive antenna(s)

* noncontiguous

e) Commission's Suggested Small Satellite RF Characteristics

The Commission also puts forward a group of RF characteristics that are "generally consistent" with Part 5 license applications filed by small satellite users and seeks comment on these characteristics.[67] CSSMA's members are currently using both Part 5 and Part 25 licenses as well as licenses granted by other ITU administrations. When these systems were in their infancy, the data rates and bandwidths put forth in the *Smallsat NPRM* were typical. However, CSSMA provides Table 3 below as an attempt to capture the Commission's identified characteristics and then our membership's estimates of the current and anticipated characteristics of typical and advanced small satellites used by its operators. CSSMA is actually being conservative as it is including only cubesat or cubesat-like systems and not systems with masses

[67] *See id.* ¶ 58.

as large as 180 kg. CSSMA also notes that unlike beginning systems designed and operated by universities and radio amateur groups, the listed system characteristics are indeed commercial; there exists a business incentive to optimize revenues achieved even by these small sized space constellations. Hence, the characteristics in columns C and D of Table 3 are more likely to apply to users of the Streamlined Process (as opposed to the Part 5 process).

Table 3: Commercial Small Satellite Spectrum Utilization & System RF Characteristics (per satellite)

A	B	C	D
Characteristic	***Smallsat NPRM*** **Assumption (Commission & ITU)**	**Current Typical Small Satellite Values**	**Current Commercial Values (Active Part 25s)**
Small Satellites Operating below 1 GHz			
Occupied Bandwidth	10 kHz to 100 kHz	10 kHz to 10 MHz	40-200 kHz (at UHF)
Satellite Antenna Gain	+3 dBi	3 to 6 dBi (typical)	6 dBi (maximum)
Satellite Transmit Power	>1 Watt	1 to 8 Watts	1 to 4 Watts
Small Satellites Operating in 1+ GHz ***			
Highest Operating Frequency Used	3 GHz	2 to 14 GHz	26.80 GHz
Occupied Bandwidth	<100 kHz	10 to 50 MHz*	@26.8 GHz: 90 MHz* @8.2 GHz: 180 MHz**
Satellite Antenna Gain	+10 dBi	0 to 27 dBi (X-band)	5 to 23.5 dBi
Satellite Transmit Power	<1 Watt	.5 to 2 Watts	.5 to 2 Watts

A	B	C	D
Characteristic	***Smallsat NPRM*** **Assumption (Commission & ITU)**	**Current Typical Small Satellite Values**	**Current Commercial Values (Active Part 25s)**
Satellite Transmit Maximum EIRP	10 dBW	2-50 W (+3 to +17 dBW)	≥ 100 W (20 dBW)

***** Current data rates go up to 320 Mbps; future data rates may go up to 2.2 Gbps by 2020. Next generation satellites will use 220 MHz by 2019 and 600 MHz by 2020. Spectral efficiencies will be 4.3 bits/symbol; in the future, they will go up to > 6 bits/symbol.
** Current data rates go up to 450 Mbps; future data rates may go up to 900 Mbps by 2020. Next generation satellites will use 300 MHz in both Right Hand Circular Polarization & Left Hand Circular Polarization by 2020. Spectral efficiencies will be 4.3 bits/symbol.
*** Current operators are already using high microwave and low millimeter wave FSS, MSS, and EESS frequency bands.

f) Optical Links and Inter-Satellite Links

The Commission is also seeking comments as to whether inter-satellite links or, alternatively, optical links, might be used by small space systems to facilitate larger bandwidth transmissions.[68]

Optical links, in and of themselves, simply are not a complete solution to small satellite spectrum needs. CSSMA membership includes some companies already working on optical links to be placed on small satellite platforms.[69] This technology is also moving rapidly forward, and there are many more companies in several countries in various research and development phases developing satellite laser communications. While trials of this technology may start within the next year, it will take some time to commercialize. And, even strong optical link advocates acknowledge that optical link systems will only be practical in a subset of operational

[68] *See id*.
[69] *See, e.g.*, Experimental License Grant, Analytical Space, File No. 0044-EX-ST-2017 (granted Apr. 5, 2018).

environments due to the pointing requirements, power usage, and high atmospheric attenuation that come with optical links.[70]

Inter-satellite links offer a different set of advantages and disadvantages, but again, are not a complete solution to small satellite spectrum needs. NGSO-to-NGSO relaying is currently viable and has been demonstrated by multiple small satellites, which relay narrowband data streams via both Globalstar, Inc. ("Globalstar") and Iridium Communications Inc. ("Iridium").[71] Inter-satellite links can work well to support TT&C functionality. But, for these existing systems, the in-orbit performance, established originally for voice-grade communications, limits the possibility for high data rate transmission. Data rates in the 10 to 100 Mbps range are required for remote sensing missions being carried out by small satellites as noted in Table 1 above. Small satellite NGSO-to-geostationary ("GSO") links are potentially viable using spacecraft like the United States Government Tracking and Data Relay Satellite System or a variety of FSS GEO systems with even higher gain spot beams. Other alternatives include MSS GEO systems like Inmarsat plc's ("Inmarsat's"). However, link budgets suggest that even with significant G/T capability at GEO, the LEO small satellite space station would be required to produce an EIRP level that is too demanding. Links currently being achieved by the CSSMA Part 25 small satellite license holders (which currently range from 35 to 450 Mbps) could not be closed between a NGSO small satellite and a GEO spacecraft using even a high gain spot beam on the GEO system due to the extra path loss of a LEO-to-GEO link.[72] However, some medium data rate mission

[70] See, e.g., Caleb Henry, *Commercial laser comm edges closer to reality*, SpaceNews (June 26, 2018) ("The catch is optical links are weather sensitive.").
[71] *See, e.g.*, Stamp Grant, Astro Digital U.S., Inc., File No. SAT-LOA-20170508-00071 (granted and deferred in part Apr. 12, 2018) (using Globalstar links).
[72] For example, a 6U EESS small satellite in a 500 km orbit, operating in Ka-band, and using a 3-meter diameter dish on the ground can close such a link with a commercial margin (6 dB). Average data rates over a pass for this satellite are realistically >100 Mbps. If that same 3-meter aperture antenna were placed in orbit at GEO altitude, the

types (non-imaging EESS for instance) could be well served by inter-satellite links. It looks as if the limit in data rate, based on the EIRP limitations associated with the small satellite uplink, is on the order of 0.5 to 1.0 Mbps. Therefore, like optical links, inter-satellite links, in and of themselves, are not sufficient to serve small satellite spectrum needs.

g) Additional Technical Rules

The Commission inquires whether the existing Part 25 technical rules should apply to small satellites and whether particular service rules, on a band-specific basis, may be needed to ensure protection of incumbent users.[73] CSSMA believes that such additional rules do not serve the public interest for the reasons set forth in Section III.B.1.b above.

2. Compatibility and Sharing with Federal Users

The Commission is seeking comment on whether procedural methodologies or cooperative arrangements might be adopted to help streamline sharing between Federal operations and small satellite applicants.[74] As the Commission no doubt realizes, many of the bands needed by small satellites as specified in Table 2 are bands shared on a co-primary basis between non-Federal and Federal users, so a productive and open-minded approach on both sides is necessary to realize the potential of small satellites in the United States. CSSMA's response here is informed by the experience of its members, which have coordinated with Federal

added link loss (from LEO to GEO) is approximately 24 dB. To close the link with the same margin as above, there would need to be a data rate reduction (100 Mbps – 24 dB ≈ 400 kbps), which is an unacceptably low data rate for commercial remote sensing. Therefore, the small satellite antenna aperture must be much larger, the RF transmitter power must be much higher, or the transmission time for the same amount of data must be much longer. An advantage to the LEO/GEO approach is that the NGSO could be visible to the GEO for more than one half of the NGSO's orbit period. That is longer than a 10-minute overhead pass at a typical Earth station. However, in terms of throughput achieved per orbit, this added link time does not come close to offsetting the 24 dB (or 250X) reduction in data rate imposed by the link from LEO-to-GEO. Thus, a LEO-to-GEO inter-satellite link using small satellite technology, at 100 Mbps speeds, is still not yet viable.

[73] *See Smallsat NPRM* ¶ 59.

[74] *See id.* ¶¶ 60-61.

agencies under Part 25. Much more can be done to share the lower frequency bands where sharing is truly more challenging. CSSMA believes there are still further opportunities to improve the efficiency of the coordination process.

CSSMA believes one or more of the following solutions could be implemented to make coordination between Federal users and small satellite applicants more efficient and successful.

1) A database, on a band-by-band basis, should be put together and should reflect the "knowable" information about spectrum usage in each band. CSSMA's members do not find the existing NTIA Government Spectrum Compendium and Use Reports to be complete (or updated) with all the information required for coordination.[75] The database CSSMA proposes should include information collected about both Federal and non-Federal systems. It should include, but not be limited to, information regarding the funding status of the programs (both Federal and non-Federal), launch and key activity dates, basic technical information regarding bandwidths, channelization plans, ground station locations (both domestic and foreign), and basic G/T and EIRP information. It should be updated regularly. Access to the database should be made available to Federal employees and contractors who have a need to know it and to non-Federal applicants evaluating using the Streamlined Process. Such a database, with open access, would foster a far more efficient and effective coordination process.

2) Mandatory pre-coordination meetings should take place between applicants and representatives of all affected Federal agencies. CSSMA would recommend this meeting takes place shortly after the filing of an application with the Commission, ensuring that

[75] *See generally Federal Government Spectrum Use Reports 225 MHz – 7.125 GHz*, NTIA, *https://www.ntia.doc.gov/page/federal-government-spectrum-use-reports-225-mhz-7125-ghz* (last visited July 2, 2018).

Federal agencies are only pre-coordinating serious applications for which the application fee has been paid. It will also provide potentially months of time for pre-coordination. The NTIA and Commission representatives dealing with the related applications should be invited and encouraged to come to such meetings. Minutes should be kept and should be reviewed by all parties present, and copies should be made available to the Commission and NTIA personnel involved in the related license application(s). These pre-coordination meetings will facilitate a more rapid closure on coordination matters. As the Streamlined Process increases the number of applications, standard pre-coordination meetings would help ease burdens on Federal agencies.

3) As CSSMA mentions above, formal coordination should begin concurrently with public notice, so that formal coordination can potentially be completed concurrently with the public notice period.

4) For pre-coordination and formal coordination, CSSMA requests that such meetings operate under a principle that time-is-of-the-essence and that a reasonable schedule be maintained for the resolution of coordination activities, leading to a positive and timely outcome. Failure of Federal agencies to act in a timely manner truly does prejudice commercial companies by causing missed launches and lower service levels to customers and missing time to market advantages.

But, in the end, if there is not a meaningful change to the coordination process (such that there is a free flowing exchange of system requirements and specifications and applications are coordinated in a timely manner), then CSSMA's recommendation in these cases regarding these critical bands (where non-Federal users have co-equal rights to the same spectrum resource) is to divide the band into sub-bands with one sub-band available exclusively to the Federal side of the

United States Table of Frequency Allocations and one sub-band available exclusively to the non-Federal side of the United States Table of Frequency Allocations.

Furthermore, CSSMA notes that these discussions involving such shared bands ignores the reality that all of the shared bands under discussion are also allocated, on the same primary basis, by all other administrations of the world. The length of the NTIA coordination process and the effect of a non-concurrence by NTIA in precluding an ITU filing both can have the effect of prejudicing a United States company's ability to establish international spectrum rights.

3. Small Satellite Operations as an Application of the MSS

The Commission asserts that it may be appropriate to permit small satellite operations in selected bands allocated to the MSS and inquires as to whether such operations should in all cases be on a non-interference, unprotected basis or whether the operations may have status in the frequency band, provided that the satellites operate consistent with any limitations on the MSS allocations and have demonstrated compliance with the small satellite process in section 25.122.[76] CSSMA appreciates the Commission's efforts to include small satellite operations as non-traditional MSS, allowing licensees to access additional frequency bands. Under this arrangement, however, small satellite operations should have the same status as MSS operations in the particular frequency band. Equal status is possible as small satellite operations will adhere to any applicable limitations on the MSS and can perform the sharing techniques described infra in Section III.C.1 to mitigate interference concerns to other in-band and adjacent-band services with status. Receiving only non-interference, non-protection status provides the streamlined

[76] *See Smallsat NPRM* ¶ 62.

applicant no regulatory certainty necessary to prove its technology viability or rely upon for business continuity.

C. Discussion of New Small Satellite Operations in Select Bands

The Commission seeks comments on the utility of various bands for use by small satellites.[77] As noted, there is a critical need for spectrum that could be used for TT&C purposes by small satellites and, for practical reasons, any frequency band between 120-1000 MHz could be used for this purpose.[78]

1. Methods of Sharing

Before turning to each band proposed by the Commission, CSSMA wants to define certain methods of sharing that it refers to throughout the remainder of these comments and which can help the Commission with its stated goal to increase the efficiency of spectrum usage in these bands.[79]

CSSMA believes that it is potentially time to consider some major adjustments to how users share lower frequency satellite spectrum (VHF and UHF bands). Many radio regulations reflect thinking from many decades ago, and technology has changed by many orders of magnitude since that time. The current ITU coordination process tries to prevent spectrum warehousing but can often have the opposite effect. What if a channel is not owned for a time; rather, it is borrowed for a time? In this age, it is now possible to digitally and dynamically adapt the needs of users (even commercial operators, which can share a channel among several operators on some non-permanent basis). Such approaches are not new and have been used with

[77] *See id.* ¶¶ 63-69.
[78] *See supra* Tables 1-3.
[79] *See Smallsat NPRM* ¶ 1.

the mobile services. Below CSSMA suggests multiple means by which sharing could occur, increasing the efficiency and utility of the spectrum.

1) *Regional Sharing*: Assuming the majority of users of these bands are NGSO-like (and specifically not GSO systems) a region can be defined as an area on the Earth's surface with a diameter such that all the channels within a band can be spatially shared and reused again (*i.e.*, one satellite in one region would not see an Earth station in another region). For instance, for a 500 km NGSO satellite, there might be approximately ten such regions around the Earth. This method of sharing, while presenting issues at the regional boundaries, is the easiest notional means of sharing. Sharing in this manner is all about working out the boundary conditions satisfactorily.

2) *Spatial Sharing:* Reusing a channel by minimizing in-line interference via directive beam antennas, at low frequencies, is limited to Earth station beam sizing. While many Federal systems may have Earth stations with relatively wide beams[80] in UHF bands, commercial small satellites systems could find it acceptable to use narrower beams and relatively low power levels in both directions to perform TT&C satellite functions. In fact, the directivity of such stations may not be entirely necessary to complete the required links, but this directivity might allow sharing with a co-channel Federal system by minimizing in-line interference events. This method would work particularly well at higher frequencies.

3) *Frequency and Time Sharing*: FDM and time division multiplexing ("TDM") are both common techniques used today including in some VHF/UHF bands. Examples include

[80] TIROS, ARGOS, and GOES user uplinking antennas are examples.

the FDM channelization of the VHF for terrestrial use by the military[81] and between ORBCOMM Inc ("ORBCOMM") and National Oceanic and Atmospheric Administration ("NOAA") in the 137-138 MHz band.

4) _Third Party Automated Coordination/Honest Broker_: Conceivably, there could be a third-party "honest broker," which coordinates the transmission times between many operators using a private database of satellite system information and arbitrates incoming transmission schedule requests between operators, thus allocating transmission frequency and time slots in a manner that optimizes the capacity for all the operators within their needs.[82] Such a system could even account for the priority and preemptive access needs of critical systems.[83] Many small satellite operators already employ the services of a ground system provider who serve many missions and these providers may be ideally situated to offer such a brokering service. CSSMA believes that by using the honest broker concept and by using priority and preemptive access to assure link availability to high value or highly critical services, such a sharing process is clearly in the public

[81] For example, in the frequency band 148-150.05 MHz, the United States military has adopted a 30 kHz channel spacing, and the Canadian military uses a 25 kHz channel plan.

[82] CSSMA notes that the honest broker is a lot like the software technology used by GSO systems (such as Inmarsat) to assign traffic to their FDMA channels. The method used is known as a Demand Assignment Multiple Access ("DAMA") system. A DAMA system, primarily, receives requests for service from subscribers and assigns their terminals to FDMA channels on a first-come, first-served basis. So, in this proposal, the honest broker is performing a DAMA function _within_ AND _between_ multiple systems. Demands for traffic assignments come with a priority ranking number ("PRN") attached (for simplicity, it can be a number between 0 and 9). A PRN of 9 might be given, for instance, to a Federal user that has traffic to send involving the safety and regularity of the flight of an aircraft, and a priority ranking number of 0 might be given to a commercial container at sea that reports its temperature and position once per day. Traffic is then prioritized by the UTC time it was received by the honest broker and its PRN. Higher-numbered PRNs are given higher priority in the assignment queue once the spectral band begins to approach its time-frequency capacity limit. When the system is at lower fill levels, the priority ranking number can be ignored as all requests can all be satisfied. Notice that while CSSMA assumes in this scenario that the flow of traffic is handled by an independent and by separate satellites with potentially different purposes, it is also possible for Federal and non-Federal users to share a common satellite in this manner.

[83] The Federal Aviation Administration's Future Aeronautical Navigation Systems Working Group-3 studied a priority based multiple access system. This approach has great merit here.

interest as it optimizes the number of operators that can share the spectrum, and it greatly enhances spectral efficiency (*e.g.*, bits/Hz and temporal channel occupancy).

5) *Code division multiple access ("CDMA") and Random Multiple Access Sharing*: CDMA is another very valuable method of sharing spectrum particularly for the higher frequency bands given the bandwidth limitations of the lower bands. There are, as well, many types of Random Multiple Access ("RMA") sharing possible that can have a particularly important role to play for bands shared with land mobile terrestrial users and small satellites.[84]

2. 137-138 MHz and 148.0-150.05 MHz

The Commission points out that these bands were intended for use by multiple satellite systems and seeks comments on whether and how small satellite space operations could share this spectrum while protecting ORBCOMM's existing and future operations.[85] CSSMA discusses the ability of small satellites to meet existing requirements in this band and the feasibility of sharing in this band with ORBCOMM and others below. A more thorough technical analysis supporting this discussion is in Annex 1.

The Commission's proposal to use these bands is near the low end of the range of feasibility due to the physical antenna size being much larger than the satellite bus size. However, quarter wavelength antennas have been deployed successfully by CSSMA member's spacecraft using in VHF under both Part 5 and/or Part 97 of the Commission's Rules, so CSSMA does believe that these bands are useable by at least some small satellite operators. It is also

[84] *See infra* Annex 1 (description of the dynamic channel assessment and assignment system ("DCAAS") method).
[85] *See Smallsat NPRM* ¶¶ 64-67.

likely that rapid technological development helps to solve some of the technical challenges with these bands. Therefore, they should certainly be considered for use in the Streamlined Process.

a) Meeting Existing Requirements of 137-138 MHz

The 137-138 MHz band, as noted by the Commission, is allocated only to space services domestically (although there are some secondary allocations made outside of the U.S. to the fixed and mobile services).[86] Hence, sharing in this band within the United States primarily involves coordination only with other space stations. CSSMA notes that there are channelization plans and flux density limitations that presumably protect other space and terrestrial services. In particular, there are several MET-n channels used by NOAA, several 15 kHz wide channels used throughout the band by ORBCOMM, and several more segments allocated to possible future non-voice, non-geostationary Mobile-Satellite Service ("NVNG") operators.[87] There is a coordination trigger at -125 $dBW/m^2/4$ kHz PFD (space to Earth) in accordance with ITU RR Appendix 5, Annex 1, Article 1.1.1, which protects the aeronautical mobile services.[88] As a practical matter, this VHF band would provide some value to small satellites and some such systems may be able to meet the technical rules, footnotes, and sharing requirements of this band as discussed further in Annex 1.

b) Sharing Among Small Satellite Users in 137-138 MHz

The Commission might assign some portion of this VHF band that is currently reserved for future possible NVNG systems to be used by Streamlined Process applicants as though all applicants were equivalent to another NVNG operator. A similar channelization plan to that used by ORBCOMM and NOAA could be employed and arbitrated by an organization, such as

---

[86] *See id.* ¶¶ 64-65.
[87] *See infra* Annex 1 (Figure A1-1).
[88] *See* ITU Radio Regulations, Appendix 5, Annex 1, Article 1.1.1 (2016).

CSSMA. It would be an "international frequency coordination group," which would organize the coordination of this collection of channels on a mission-by-mission basis. A prototype or model for such an organization could be the Satellite Coordination Committee of the International Amateur Radio Union ("IARU").[89] This committee has, to-date, coordinated 496 small satellites that have operated (or will operate) within Amateur Radio Service bands[90].

However, a more dynamic frequency and time management plan might make more efficient use of this spectrum whereby a "honest broker" (which may be automated) arbitrates/coordinates the transmission channels and times between many operators, thus optimizing the capacity for all the operators within their needs. The "honest broker" would enable a larger community of operators to share the band. CSSMA understands that such a system would require development, but such innovation is possible within the small satellite community.

c) Meeting Existing Requirements of 148.0-150.05 MHz

This frequency band is put forward by the Commission as a possible option for Earth-to-space (Command) links for small satellites operating under the Streamlined Licensing Procedure.[91] This band, however, is quite different in character from the "companion" VHF band at 137-138 MHz as it is shared with many existing terrestrial users. ORBCOMM resolved the coordination challenges with the terrestrial users with a concept known as DCAAS.[92] This method scans the frequency band rapidly and repeatedly and establishes the channel occupancy

[89] *See generally Amateur Radio Satellite Frequency Coordination*, IARU, www.iaru.org/satellite (last visited July 7, 2018).
[90] *See List of Satellite projects for which frequencies have been coordinated*, IARU, http://www.amsat.org.uk/iaru/ (last visited July 7, 2018).
[91] *See Smallsat NPRM* ¶¶ 66-67.
[92] *See ORBCOMM System Overview*, ORBCOMM at E.2 (Dec. 18, 2001), https://www.ctu.cz/sites/default/files/cs/download/oznamene_typy_rozhrani/orbcomm-rozhrani_02_06_2010.pdf.

statistics for each 15 kHz within the uplink band 148.000-150.050 MHz. Based on the statistics of channel occupancy, the least occupied channels were found. From this list of "available" channels, channels are selected and used by the system for the next M seconds, and then, the process repeats.

Small satellite systems could employ a similar DCAAS system for the selection of a clear channel for the command uplink, use similar EIRP levels and channel bandwidths as ORBCOMM emissions, and also use higher directivity Earth stations antennas. These measures would reduce the potential for in-line interference with ORBCOMM. Furthermore, there would be no need for formal coordination procedures among operators with such a dynamic allocation of frequencies. A more detailed description of the DCAAS form of RMA sharing is provided in Annex 1.

d) Sharing Among Small Satellite Users in 148.0-150.05 MHz

The DCAAS system mentioned above would facilitate sharing among small satellite users of this band as well. See Annex 1 for a more detailed discussion of such sharing.

e) International Coordination

Both of these proposed VHF bands would require coordination of small satellite space stations under Article 9 of the Radio Regulations.[93] While these bands should certainly be available to small satellite applicants, bands subject to mandatory coordination are unlikely to be obtained in an expedited manner. The band 137-138 MHz could require such coordination as a practical matter as other administrations may authorize space stations that could occupy the same

[93] *See* ITU Radio Regulations, Chapter II (2016). The 137-138 MHz band contains FN 5.208, which requires station coordination under Article 9.11A. The 148-150.05 MHz band contains FN 5.218, which requires coordination under Article 9.21.

band. CSSMA believes that its proposed sharing methodology would protect at least the ORBCOMM system. However, if other administrations were to authorize additional MSS or small satellite systems that were not utilizing the proposed dynamic channel coordination methodology, then the only remedy would likely be Article 9.11A/9.21 coordination.

Coordination in the 148-150.05 MHz band is another matter.   Given the reality of space systems sharing in a heavily occupied band filled with mobile and fixed station VHF traffic and the only practical means for space systems to share this band with such terrestrial users is by means of adaptive dynamic frequency assignment (orchestrated, in fact, by the space segment of the system), it is hard to see how coordination via the ITU process really matters or could be reasonably effective. A space system simply could not be assured of further protection nor could a system become meaningfully further harmed by another space system interferer (*i.e.*, an uplinking Earth station having the same operating characteristics as hundreds to thousands of other signals); therefore, coordination under Article 9.11A/9.21 would not be effective or useful.

3. 1610.6 -1613.8 MHz

he Commission requested comments on whether small satellites could operate in the 1610.6 –1613.8 MHz band as an application of MSS under the existing uplink allocation.[94] Under such circumstances, small space systems would employ this frequency band to satisfy Earth-to-space link requirements. Once again, CSSMA's preference would be for Streamlined Process applicants to use the bands as they are allocated per category of service as CSSMA's member's commercial interests span a wide range of service categories. It has concerns that the Commission would have to "bend" too many existing rules to accommodate these systems simply

[94] *See Smallsat NPRM* ¶¶ 68-69.

because the systems were categorized as "small satellites." However, CSSMA is supportive of the Commission's proposal if radio regulations and service rules can be modified or added so that small satellites, regardless of their actual service category, could be licensed in this band. It is also the case that many CSSMA members intend to deploy systems that are intended to operate as a part of MSS in any case.[95] These systems would particularly benefit from the Streamlined Process associated with this *Smallsat NPRM*.

CSSMA discusses the ability of small satellites to meet existing requirements in this band and the feasibility of sharing in this band in Annex 2.

CSSMA is not certain why the Commission identified this smaller portion of the MSS NGSO (Big LEO) spectrum, so it suggests that the remainder of the overall MSS band between 1613.8 and 1626.5 MHz be considered for small satellite use for the reasons stated in the following subsections.

a) Meeting Existing Requirements of 1610.6 -1613.8 MHz

CSSMA believes that small satellite system characteristics can be made to be compatible with MSS users using the Globalstar system, Radio Astronomy Service ("RAS") operators, and Radio Navigation Satellite Service ("RNSS") operators.

1. *Compatibility with Globalstar*: Globalstar operates its system RETURN link in the lower half of the frequency band from 1610.0 MHz to 1626.5 MHz while Iridium operates in both link directions (FWD+RTN) in the upper half of the overall band.[96]

---

[95] *See, e.g.*, Petition for Declaratory Ruling, Kepler Communications Inc., File No. SAT-PDR-20161115-00114 (filed Nov. 15, 2016).

[96] *See 1613.8-1626.5 MHz*, NTIA, https://www.ntia.doc.gov/files/ntia/publications/compendium/1613.80-1626.50_01MAR14.pdf (last visited July 8, 2018) ("Globalstar operates in the 1610.73 to 1618.73 MHz portion of the band and Iridium operates in the 1618.73 - 1626.5 MHz portion of the band.").

CSSMA focuses in this discussion on the Globalstar system portion as the Commission's proposal in the *Smallsat NPRM* involves the subject band segment. Globalstar's system uses CDMA technology to enable multiple users in the band.[97]

CSSMA believes small satellite systems can share spectrum with the Globalstar system in the Earth-to-space direction using directive antennas and an uplink power flux density ("PFD") level that would present a signal in the Globalstar satellite receiver no larger than the largest amplitude CDMA uplink signal that would be encountered by one of its own hand-held earth terminals. As the Globalstar orbit at 1414 km is more than 2 times higher in altitude than the orbits being discussed for small satellite systems operated under the Streamlined Process, the signal strength reaching small satellite space stations would be at least 6 dB higher in PFD than those signals reaching Globalstar satellites (on average), enhancing the uplink performance to these small satellites. The small satellite systems could adopt a similar CDMA system as Globalstar, which enables many simultaneous small satellite operators by making them look like additional subscriber signals to the Globalstar system. Further protection would be afforded to the Globalstar system by using higher directivity antennas for small satellite Earth stations (while maintaining the EIRP at Globalstar subscriber signal levels). Thus, in-line events would only occasionally occur. It is only during such events that a Globalstar satellite would actually be able to detect the in-line signal from a small satellite Earth station. The details of this sharing process are presented in Annex 2.

[97] *See How the Globalstar (CDMA) works*, Globalstar, https://www.globalcomsatphone.com/globalstar-information/how-cdma-works (last visited July 8, 2018).

2. *Protection of the RAS:* The Commission suggests that to minimize interference from small satellite Earth stations to RAS receivers, small satellite system Earth stations seeking to operate in this band could demonstrate that they are not within certain exclusion zones, related to United States RAS sites as identified in Section 25.213 of the Commission's rules.[98] CSSMA believes protection of the Radio Astronomy community is critically important and agrees with this recommendation.

3. *Protection of RNSS:* The Commission proposes out of band emissions limits in section 25.216 be applicable to Streamlined Process applicants operating in this band to protect RNSS operators.[99] CSSMA believes the emission levels (EIRP densities) identified in the current version of Section 25.216(c)[100] could be acceptable as a condition for operation by small satellite operators. To be clear, CSSMA's interpretation of this section is that small satellite Earth station emissions must not exceed -70 dBW/MHz over any two-millisecond active transmission interval.

b) Sharing Among Small Satellite Users in 1610.6 -1613.8 MHz

CSSMA believes that sharing among small satellite users in this band is very feasible. Particularly, if a CDMA system similar to Globalstar is adopted by small satellite users, sharing among small satellite users would be essentially the same as sharing with Globalstar space stations. In-line interference events would be rare and of very short duration, and the interference levels, in this case, would be the same as having two (and only two) CDMA signals attempting to code share on the same channel, meaning there would be no interference to either satellite even during an in-line event. For a detailed discussion of this sharing method, see Annex 2.

[98] *See Smallsat NPRM* ¶ 69; 47 CFR § 25.213.
[99] *See Smallsat NPRM* ¶ 69.
[100] *See* 47 CFR § 25.216.

4. Use of MSS and FSS Frequency Bands for Inter-Satellite Links with Small Satellites

The Commission has investigated the concept of communication links between MSS and FSS satellites and seeks comments on whether using links (in either direction) via Globalstar or Iridium could alleviate some of the difficulties faced by small satellite operators in identifying frequencies that could be used for uplinks and downlinks and with respect to offsetting ground station needs and requirements.[101]

CSSMA believes that, while a few of its members have used Globalstar and/or Iridium for demonstration purposes, small satellite systems do not yet make routine use of MSS systems for two-way communications. Various cubesat missions have previously used Globalstar, primarily in the context of one-way communications via the RETURN link. Also, there are several ongoing trials related to two-way communications using Globalstar. CSSMA-member Astro Digital has, in fact, been granted a Part 25 license (in part) to use Globalstar for one satellite in its 30-spacecraft constellation.[102] That satellite can only use Channels 5 and 6 of Globalstar from approximately 1615.29-1617.75 MHz to assure no interference will occur to RAS or to Iridium customers (strictly due to out-of-band, adjacent channel interference). Astro Digital reports that while two-way communications have been established on many occasions via the inter-satellite link, hand-off processes between beams and between two Globalstar satellites is complex, and many software adjustments are being made. In addition, parameters such as satellite beam footprint coverage, Doppler shift characteristics, terminal power control, beam-beam handoffs, satellite-satellite handoffs, and gateway location effects have to be taken into account as one of

---

[101] *See Smallsat NPRM* ¶¶ 70-74.

[102] *See* Stamp Grant, Astro Digital U.S., Inc., File No. SAT-LOA-20170508-00071 (granted and deferred in part Apr. 12, 2018).

Astro Digital's Landmapper satellites flies underneath satellites in the Globalstar constellation. The Globalstar system was not designed with inter-satellite links in mind, and as a result, technical challenges similar to those faced by Astro Digital remain.

Over time, if and as these issues are overcome, it is very likely that both Globalstar and Iridium MSS systems could offset *some* of the needs of, particularly, TT&C links for future small space systems.[103] CSSMA can also confirm that there are significant advantages to purchasing inter-satellite link capacity as an alternative to constructing an equivalent ground network with a sufficient density to provide the equivalent performance of these MSS systems. In addition, true global coverage using these MSS systems is theoretically possible.

Regarding allocation authority and category of service issues, CSSMA reiterates that it does not think it is necessary to re-define MSS, FSS, or Inter-Satellite Service for the sake of small satellites. Rather, small satellites should be allowed to participate within these service categories. The issue is a matter of the duration of the process required to obtain authority to operate. As the radio regulations stand now, CSSMA agrees that the best way forward to authorize communications for small satellites (and large ones) via L-band inter-satellite links is by creating a footnote authorizing inter-satellite communications, co-primary with MSS, within the Globalstar and/or Iridium bands (including the 2483.5-2495 MHz s-E band). CSSMA fully supports that such communications should not cause harmful interference to RAS sites. And, to that end, inter-satellite communications (by large and small systems) should be restricted to start only at 1613.8 MHz within the overall band 1610-1626.5 MHz. A more thorough technical analysis supporting this discussion is in Annex 2.

[103] If small satellites use existing Globalstar and Iridium modem equipment on-board satellites, data rates are limited to the range 9600 to 2400 bps, which is only sufficient in most cases for TT&C communications.

Overall, CSSMA supports opening up the use of inter-satellite links as such links are a very valuable avenue to help address increasing spectrum congestion; they allow for space-to-space operations that help to distribute spectrum usage across less congested parts of an orbit such as when over the ocean. CSSMA encourages the Commission to look at inter-satellite links in other bands as well including those referenced in Section III.D below.

D. Other Bands For Consideration

The Commission seeks comments on additional bands that it might consider for the Streamlined Process.[104] CSSMA believes that the most important bands to the small satellite community are as listed in Table 4. Many CSSMA members are actively using these bands at the moment or, in some instances, have filed applications for licensing within these bands.[105] However, we do feel that there are other frequency bands or regions of the spectrum, that the Commission should consider for use by small satellites.

We summarize in Table III.D. those frequency bands that seem to have merit for further review and discussion. For each Frequency Band, we provide the link direction that is consistent with the existing US Table of Allocations, except for 8025-8400 MHz where we are proposing a new space-to-space allocation. For Suggested Category of Service, we include both currently applicable categories and suggested additional categories that could be added to the US Table of Allocations.

---

[104] *See Smallsat NPRM* ¶¶ 58, 63.
[105] *See supra* note 2.

Table 4: Other Bands and Regions of Spectrum Potentially Beneficial or Critically Important to Small Satellites

Frequency Band	Link Direction	Suggested Category of Service
Short Duration NGSO	(Earth-to-space) (space-to-Earth)	MSS, SOS, EESS
1525.0-1535.0 MHz	(space-to-Earth)	MSS, SOS, EESS
1535.0-1559.0 MHz	(space-to-Earth)	MSS, SOS, EESS
1613.8-1626.5 MHz	(Earth-to-space)	MSS, SOS, EESS
1626.5-1660.0 MHz	(Earth-to-space)	MSS, SOS, EESS
2483.5-2495.0 MHz	(space-to-Earth)	MSS, SOS, EESS (non-imaging)
2495.0-2500.0 MHz	(space-to-Earth)	MSS, SOS, EESS (non-imaging)
8025-8400 MHz	(space-to-space)	EESS, FSS, Meteorological Satellite Service
20-150 GHz	Both link directions	EESS, FSS, MSS, SRS, SOS

For the reasons set forth below, the Commission should explore all of these bands for use by small satellites.

Short Duration NGSO: Working Party 7B Agenda Item 1.7 is considering the allocation of additional SOS spectrum for Short Duration NGSOs, which is similar to but not entirely consistent with the definition of small satellites in the *Smallsat NPRM*.[106] Still, if such spectrum

[106] *See* ITU-R Resolution 659, Studies to accommodate requirements in the space operation service for non-geostationary satellites with short duration missions (2015), https://www.itu.int/dms_pub/itu-r/oth/0c/0a/R0C 0A00000C0007PDFE.pdf.

is made available in WRC-19, it should certainly be considered by the Commission to be included in the Streamlined Process.

1525.0-1535.0 MHz: This band is allocated co-primary to MSS and EESS in all three ITU regions.[107] CSSMA notes that the United States has not picked up the EESS service category domestically. While CSSMA understands this band is used, in part by Inmarsat, there may be opportunities to implement sharing with GSO systems.

1535.0-1559.0 MHz: This E-s band is the primary GSO band for MSS downlinks.[108] As the *Smallsat NPRM* has identified MSS as a potentially favorable compatible service category, it seems plausible that sharing could occur in this band between GSO and NGSO systems given appropriate technical sharing rules being put in place.

1613.8-1626.5 MHz: For the reasons set forth in Section III.C.3 above, the Commission should consider this entire band for inclusion in the Streamlined Process.

1626.5-1660.0 MHz: This s-E band is the primary GSO band for MSS uplinks.[109] It seems even more likely to CSSMA that this band could be shared with small satellite systems using directive antennas directed away from the GSO arc. This band is often paired with the 1535.0-1559.0 MHz band.

2483.5-2495.0 MHz and 2495.0-2500.0 MHz: Taken together, these are the companion s-E NGSO MSS (Big LEO) bands. CSSMA wonders if sharing arrangements, particularly in the upper 5 MHz (where, in the end, Iridium did not go), might be able to be reached with mobile services. Solutions like the DCAAS system mentioned in Section III.C.2.c above could be implemented.

---

[107] *See* 47 CFR § 2.106.
[108] *See id*.
[109] *See id*.

8025-8400 MHz: CSSMA believe the Commission should also enable greater use of spectrum by adding space-to-space allocations in X-band between 8025-8400 MHz. The 8 GHz earth-exploration band, popularly used for remote sensing satellite downlink, is not allocated for space-to-space links. If the 8025-8400 MHz allocation was made to mirror the similar remote sensing bands in lower S-band (2025-2110 MHz and 2200-2290 MHz) in terms of having the allocation to both space-to-Earth as well as space-to-space, greater use of remote sensing satellites and more innovation would be possible. Additionally, opening up a band that is already used by many operators of high-data operations like remote sensing would allow them to use their same hardware and thus make it more accessible given the severe space and power constraints that limit the ability to add additional communication modules on small satellites.

20 – 150 GHz (Millimeter Wave Bands): This region of the spectrum is critical to realizing the full promise of small satellites. Millimeter wave frequency bands enable small, lower cost space systems. For this reason, CSSMA requests that small space systems be given some preferential treatment when it comes to the allocation of spectrum to new systems and services in the millimeter wave portion of the domestic and ITU tables of frequency allocations. CSSMA urges the Commission to consider the allocation of one to several bands in the 20-150 GHz region of the spectrum for use particularly (but not necessarily exclusively) for small space systems. CSSMA wishes to point out that despite their size and mass, such small systems are capable of highly accurate attitude control. Precise pointing of a spacecraft structure itself or various gimbal mechanisms fitted to the platform is not only possible but is common-place now with small space systems. To be specific, they have the full flexibility and accuracy of much larger satellites. And, typically, they are even more responsive (in terms of time to acquire a new attitude, target, or position) than their larger counterparts. Hence, they can be tasked to point highly directive, narrow beam antennas at receiving or transmitting target locations on the Earth's surface. To the extent that small satellite antennas can form narrow beams, coordination should be imminently feasible. Frequency reuse through spatial isolation resulting from high gain/highly directive antennas, placed on satellites in the cubesat class and their Earth stations, is now a reality. Several systems, doing exactly these tasks, are in-orbit now. However, to form narrow beams on small objects requires the exploitation of very short wavelength emissions (*i.e.*, millimeter wave frequency band use).

IV. CONCLUSION

CSSMA respectfully submits these comments to the *Smallsat NPRM* with the hope that the Commission can help create a cost effective, transparent, and expedited licensing process for small satellites. Small satellite systems promise to innovate not just with respect to space technology, cost reduction, and service quality but also in the efficient use and sharing of spectrum. If the Commission can implement a Streamlined Process that is consistent with the pace of technology development offered by small satellite systems, then the United States can continue to lead in the space sector.

Respectfully submitted,

CSSMA

/s/ Jonathan Rosenblatt
Jonathan Rosenblatt
President
575 Florida Street, Suite 150
San Francisco, CA 94110
jonathan.rosenblatt@spire.com
+1-628-221-5324

July 9, 2018

ANNEX 1 (137-138 MHZ AND 148.0-150.05 MHZ)

The technical discussion in this Annex 1 supports CSSMA's position set forth in Section III.C.2 of CSSMA's Comments to the *Smallsat NPRM*.

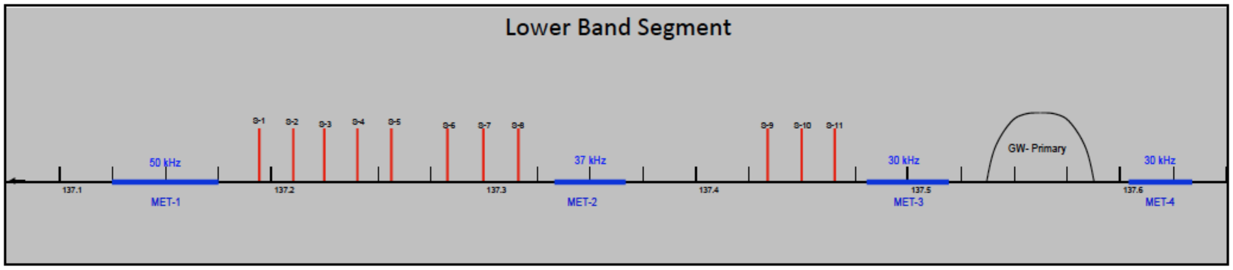
As noted in Section III.B.1, there is a critical need for spectrum that could be used for telemetry, tracking, and command ("TT&C") purposes by small satellites, and while any frequency band between 120 MHz-1000 MHz could conceivably be used for this purpose, the lower end of these frequencies creates increasing technical challenges. These challenges include the use of antenna lengths that are larger than the smallest of small satellites and the absorptive properties of the ionosphere at lower VHF frequencies. While quarter wavelength antennas have been deployed successfully by CSSMA member spacecrafts using 145.80-146.0 MHz under Part 5 and/or Part 97 of the Commission's rules, this usage is by no means common. Also, while CSSMA members have discussed the potential use of electrically-shortened antennas in these bands, this approach has the obvious impact of antenna pattern distortion and increased matching losses, making links more difficult to close. Therefore, the Commission's proposal to use VHF bands is welcome, but it is not a full solution by itself.

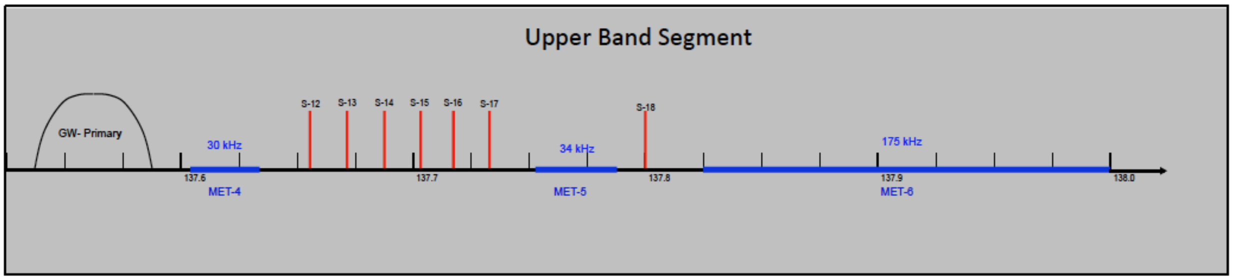
CSSMA wishes to comment on the use of these VHF uplink and downlink bands, treating them as separate cases.

1) <u>Sharing with ORBCOMM and Existing Users at 137-138 MHz</u>

CSSMA provides Figure A1-1 as a means of assisting reviewers to visualize how the 137.0-138.0 MHz band is currently shared in terms of band planning for ORBCOMM and NOAA. The plan consists of NOAA (MET-n) channels, ORBCOMM subscriber (S-n) channels, and an ORBCOMM Gateway downlink (GW-1) channel.

Figure A1-1: Band Plan





Subscriber Downlink Frequencies

Ch. No.:	Frequency (MHz):
S-1	137.1950
S-2	137.2100
S-3	137.2250
S-4	137.2400
S-5	137.2550
S-6	137.2850
S-7	137.3000
S-8	137.3150
S-9	137.4350
S-10	137.4500
S-11	137.4650
S-12	137.6575
S-13	137.6725
S-14	137.6875
S-15	137.7025
S-16	137.7175
S-17	137.7325
S-18	137.8000

Meteorological Satellite Sub-Bands

Ch. No.:	Freq. Range (MHz)
MET-1	137.125 to 137.175
MET-2	137.333 to 137.367
MET-3	137.485 to 137.515
MET-4	137.605 to 137.635
MET-5	137.753 to 137.787
MET-6	137.825 to 138.000

Gateway Downlink Frequency

Ch. No.:	Freq. Range (MHz)
GW-1	137.5625

f = 137.000 + N(0.0025); N= 225

The 137-138 MHz band, as noted by the Commission, is allocated only to space services domestically (although there are some secondary allocations made outside of the U.S. to the fixed and mobile services). Hence, sharing in this band involves (almost exclusively) coordination only with other space stations. CSSMA notes that there are PFD limitations and channelization plans that presumably protect other space and terrestrial services.

CSSMA is aware of the MET-n channels used by NOAA and about the eighteen 15 kHz wide channels used throughout the band by ORBCOMM as shown in Figure A1-1 above. As a practical matter, CSSMA believes that small satellites could “look like” an ORBCOMM satellite to other users of the band to facilitate sharing, meaning small satellite systems would utilize a 15 kHz channelization plan with the same channel centers as those used by ORBCOMM. Small satellite systems would comply with the -125 $dBW/m^2/4$ kHz PFD in accordance with ITU Radio Regulations.[110] CSSMA's understanding is that the existing ORBCOMM system does not use 100% of these eighteen channels for 100% of the time. To be clear, these are the channels that currently exist in the channelization plan.

In the *Smallsat NPRM*, the Commission points out that multiple systems were expected to be licensed in this band when the non-voice, non-geostationary Mobile-Satellite Service ("NVNG-MSS" or "NVNG") service was first created.[111] The other NVNG-MSS operators are defunct, and the Commission has allowed ORBCOMM to use some of these channels on a provisional basis subject to future systems.[112] Simply put, to the extent that all of these channels are not assigned to ORBCOMM in accordance with its license, they could be re-assigned for TT&C communications by the small satellite community. CSSMA believes that the most efficient sharing methods in this band between ORBCOMM and small satellite users would be this type of segmentation; however, the whole band might be shared among all users through some sort of dynamic sharing, which would require ORBCOMM to allow small satellite users to use parts of their licensed band and, in return, continue to use more channels than they are currently licensed to use. CSSMA looks forward to discussion with ORBCOMM on how best to share this band.

2) <u>Sharing among Small Satellite Users at 137-138 MHz</u>

Having addressed the downlink sharing mechanisms between ORBCOMM and small satellites, CSSMA needs to address the issues of sharing this band among small satellite users themselves.

CSSMA notes that some spatial sharing might also be possible if ground station directive antennas can be utilized.

The Commission might also assign the channels (used but not licensed to ORBCOMM and the other channels in the band originally assigned to NVNG) to be used by small satellites as though all

[110] *See* ITU Radio Regulations, Appendix 5, Annex 1, Article 1.1.1 (2016).
[111] *See Smallsat NPRM* ¶¶ 64-65.
[112] *See id.*

applicants were equivalent to the other original (and now defunct) NVNG operators. This structure could be N, 15 kHz channels. What would traditionally happen at this point would be for an organization, like CSSMA, to form an "international frequency coordination group," which would organize the coordination of this collection of channels on a mission-by-mission basis, where the overall capacity of these N channels would be divided up by region, channel, and time. Such a group could be a form of public/private partnership. A prototype or model for such an organization could be the Satellite Coordination Committee of the International Amateur Radio Union ("IARU").[113] To date, this committee has coordinated 496 small satellites that have operated (or will operate) within Amateur Satellite Service spectrum. [114] While IARU is a not-for-profit entity, it has been successful in coordinating a large number of disparate small satellite users into a very small number of narrowband channels within the 435-438 MHz UHF band. CSSMA, or some other public/private partnership, could use any number of coordination methods discussed *supra* Section III.C.1 to facilitate coordination in this band among small satellite companies.

CSSMA, or a similar group, could also institute a process of more dynamic frequency and time management Internet resource tool: a website/server is used as a means to focus the coordination and assignment of small satellite operators to channel/time/location resources. Coordination would be carried out by means of an "honest broker" system (*see supra* Section III.C.1) by first partitioning the resource into region/channel/time/orbit slots. A given satellite system would thus have its satellites assigned such slots on a pre-specified periodic basis by this automated form of the "honest broker." With such a system, it would achieve a spectrum management approach that is fully dynamic and spectrally efficient. While "slot" assignments at first might be long, they could ultimately be reduced to very short time intervals (*e.g.*, seconds) as the system matures and becomes more automated. CSSMA notes that, in accordance with the Streamlined Process identified in the *Smallsat NPRM*, no single operator's system would be

[113] *See supra* notes 89-90.
[114] *See id.*

assigned “slots” within the system for more than five years (or the duration of the license ultimately decided upon by the Commission via this rulemaking).

3) Sharing with ORBCOMM and Existing Users at 148.0 – 150.05 MHz

This frequency band is put forward by the Commission as a possible option for Earth-to-space (Command) links for small satellites operating under the Streamlined Process. This band, however, is quite different in character from the “companion” VHF band at 137-138 MHz discussed above.

Historically, this band has been used by Federal Systems for fixed and mobile services; however, at a prior World Radiocommunication Conference, footnote 5.218 was added, allowing Space Operations to be used in this band.[115] However, it did not displace the existing terrestrial users who still occupy this spectrum today. Federal users of this band (*e.g.*, NASA and NOAA) abandoned this VHF spectrum many years ago for Space Operations purposes although fortunately now the footnote still remains. When such Space Operations took place, sharing was feasible by having the Federal Earth stations use particularly high EIRP levels directed toward the receiving spacecraft, “suppressing” the interfering terrestrial signals arriving at the victim satellites (which were and are still FM modulated). By using a satellite command receiver that is also employing frequency modulation, it is possible to use the “capture effect” property of FM to suppress co-channel interference. The C/I for the intended signal at the satellite receiver needs to be above the “capture threshold.” This process is sometimes referred to as “buying the link.” So far as the terrestrial users were concerned, they would not receive interference from the Earth-to-space transmission so long as they were not located in the vicinity of a NASA facility. This circumstance was improved by the large, highly directional antennas used by Federal Earth stations.

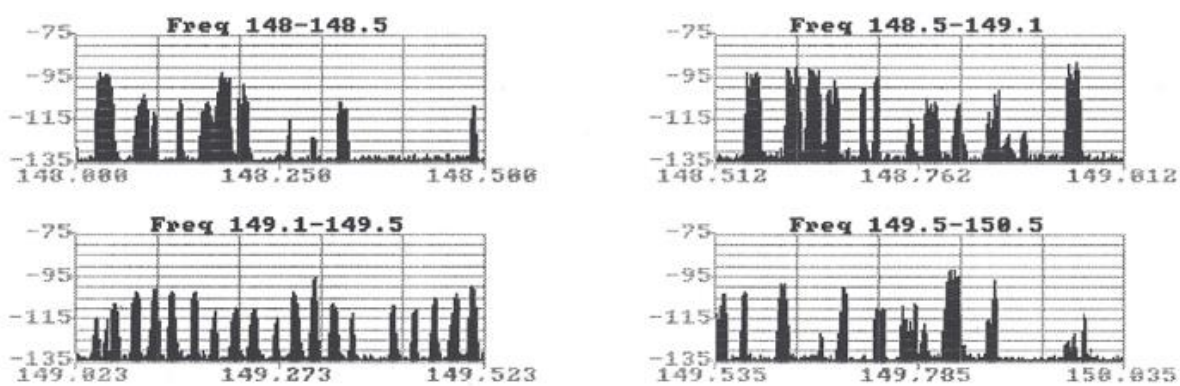
In the early 1990s NVNG-MSS was added to this band as it had demonstrated the potential for sharing between terrestrial and space services; however, a method for sharing NVNG-MSS signals with terrestrial services had to be found by ORBCOMM, which was the principle commercial applicant. The difficulty was that the old method used by Federal Earth stations could not be employed since the EIRP

[115] *See* 47 CFR § 2.106 n.5.218.

levels of ORBCOMM uplinking terminals was even below the levels of terrestrial stations. ORBCOMM could simply not "buy the link" with each of its many thousands of anticipated Earth terminals.

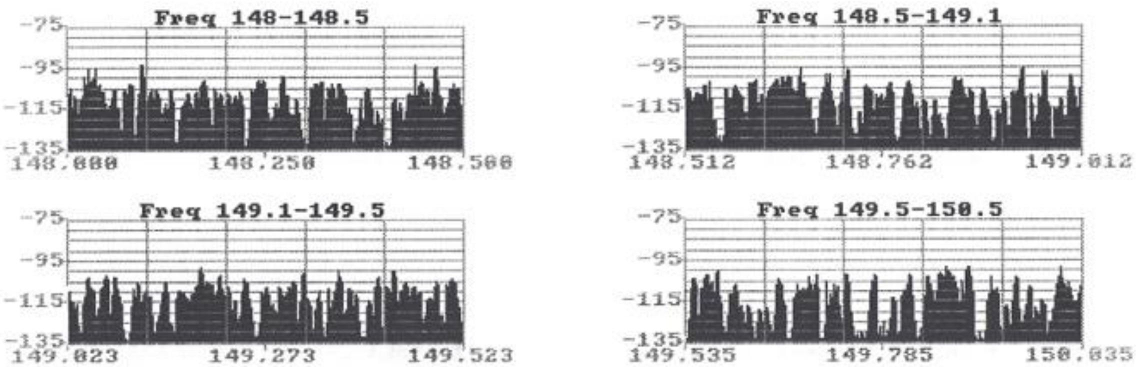
ORBCOMM's solution was to develop a concept known as DCAAS. By surveying the 148-150.05 MHz band, using an amplitude-calibrated scanning receiver, it was possible to assess the traffic patterns and amplitude characteristics of the in-place mobile user community. In some portions of the Earth, the characteristics of the emitters, as seen in a typical LEO communications orbit, was found to be as shown in Figure A1-2.

Figure A1-2: 148-150 MHz Terrestrial Emissions Seen from NGSO - Orderly



In some regional locations, a regular channelization plan was evident in portions of the band, and different classes of users were also observable. These emissions could be characterized as well defined. Gaps were also found in the utilization pattern. However, the gaps were not always on the same frequencies or in the same locations around the world. In some regions, this more orderly channelization plan did not exist as shown in Figure A1-3.

Figure A1-3: 148-150 MHz Terrestrial Emissions Seen from NGSO - Chaotic



In this instance, the usage pattern was far more chaotic, and dynamic and channel occupancy was much higher. But, gaps in the spectrum, statistically, still existed.

However, a better statistical processing method was required to make this "worst-case" scenario work effectively and find the gaps. The method adopted by ORBCOMM, given this band occupancy scenario, was to have each operational satellite contain a scanning receiver.[116] The receiver would scan the frequency band rapidly and repeatedly and would establish the channel occupancy statistics for each 15 kHz within the uplink band 148.000-150.050 MHz.[117] Based on the statistics of channel occupancy, the *least occupied* channels were found.[118] From this list of "available" channels, N were selected, and these channels were "identified" to uplinking ORBCOMM user stations (via the Forward downink), which then adjust their transmit frequencies to match these known and identified gaps.[119] These selected channels are then used by the system for the next M seconds.[120] Then, the process repeats.[121] As ORBCOMM terminals only transmit burst messages, this technique works very well. If a frequency channel does

---

[116] *See supra* note 92.
[117] *See id.*
[118] *See id.*
[119] *See id.*
[120] *See id.*
[121] *See id.*

become occupied by a terrestrial station during an ORBCOMM terminal transmission, the information is simply retransmitted again (sometimes using a new channel assignment from the list). Given the foregoing explanation, it is clear why footnote US 323 could be adopted and considered acceptable by operators like ORBCOMM.[122]

Industry is now starting a new generation spectrum utilization wave, and both it and the Commission (as evidenced by the *Smallsat NPRM*) are considering the addition of a new layer of users to the band. It is clear that the original method used by NASA and other Federal Earth stations to share with terrestrial users could not be used again; the high EIRP levels used in this approach could interfere with ORBCOMM satellites under co-channel conditions. Also, with a larger number of uplinking small satellite stations with lower directivity uplinks, local interference to Federal terrestrial stations operating in the same area with small satellite Earth stations could be caused.

However, CSSMA believes that even this new level of sharing among service categories would be possible in this band, and harmful interference can be avoided.

a) Small satellite space stations would use a DCAAS-like scanning receiver to identify the same type of vacant narrowband channels (say 15 kHz wide) as ORBCOMM does, and each small satellite space station would identify just a single "best" frequency to use for receiving the transmission of Command uplink signals.

b) The commanding small satellite Earth stations would use this dynamic frequency assignment with higher directivity Earth stations antennas and total EIRP levels similar to ORBCOMM emissions.

[122] *See* 47 CFR § 2.106 n.US323 ("In the band 148-149.9 MHz, no individual mobile earth station shall transmit on the same frequency being actively used by fixed and mobile stations and shall transmit no more than 1% of the time during any 15 minute period; except, individual mobile earth stations in this band that do not avoid frequencies actively being used by the fixed and mobile services shall not exceed a power density of −16 dBW/4 kHz and shall transmit no more than 0.25% of the time during any 15 minute period. Any single transmission from any individual mobile earth station operating in this band shall not exceed 450 ms in duration and consecutive transmissions from a single mobile earth station on the same frequency shall be separated by at least 15 seconds. Land earth stations in this band shall be subject to electromagnetic compatibility analysis and coordination with terrestrial fixed and mobile stations.").

c) Longer transmission durations (transmit duty factor), as would be appropriate for commanding such satellites, would have to be permitted.

CSSMA notes that due to the directivity and low EIRP levels of a small satellite Earth station, little or no interference would be caused (in local situations) to Federal terrestrial stations. Further, ORBCOMM satellites would only detect the presence of a small satellite uplinking station when an ORBCOMM satellite was within the directive beam of a small satellite Earth Station. When in-line events occur and such directive beams are relatively wide (say 30 ° HPBW might be typical), the PFD or spectral density at an ORBCOMM satellite from a small satellite Earth station would not be higher than any other terrestrial user it already sees on the ground (and is designed to avoid using its DCAAS receiver). Such signals would, in fact, be designed to be equal to the levels of ORBCOMM subscriber uplink signals themselves and would only occur in the event that an ORBCOMM DCAAS assignment had been made in-common with the selected command frequency of one of the small satellite system(s). As ORBCOMM and uplinking small satellite systems would use different, statistically independent, DCAAS receiver system solutions, the probability of both system receivers selecting the same uplink channel would be very low.

4) <u>Sharing among Small Satellite Users at 148.0-150.05 MHz</u>

CSSMA now suggests that this same DCAAS random frequency sharing method used by ORCOMM be used to allow small satellite stations to share this band with one another. With regard to interference on uplinks between small satellite operators, CSSMA believes that there is no need for a formal coordination procedure between operators as has been described for the downlink band and that the entire band should be used for this random and dynamic process as discussed, reducing the probability of a DCAAS channel being assigned to any two satellites situated in the same proximity. In other words, the band divisions described in the ORBCOMM proceeding for the 148-150.05 MHz band are not needed.

CSSMA observes the following "natural" protection mechanisms associated with this scheme of sharing.

a) Two small satellite terminals would only have the opportunity to interfere with one another if an in-line event occurred between two Earth stations and their corresponding satellites.

b) As both satellites are identifying empty channels on a statistically independent basis and there are approximately 136 channels across this band (using a 15 kHz channelization plan), then there is a low probability that the two independent satellites would identify and then select the same command channels for the two systems.

c) As there is minimum risk of interference to terrestrial fixed and mobile stations and to ORBCOMM space stations, as per above, CSSMA believes there could be an allowed relaxation of footnote US323 to permit a higher transmit duty cycle for small satellite Earth stations in the Earth-to-space direction. CSSMA does not believe that a 100% duty factor is necessarily appropriate nor is it necessary for most of its members' systems. However, if it can be proven that a high duty factor transmission from such stations will not result in a harmful interference case, then CSSMA believes that US323 could eventually be eliminated for small satellite licensees.

CSSMA wants to further note that in the event of an interference event between any two satellites (ORBCOMM or small satellite) the nature of the command signaling is such that no significant consequence will result from receipt of the other station's signal. The command systems will simply reject the received command, and both systems would likely have to retry their commands. As CSSMA has pointed out, this rejection would be an unlikely occurrence.

ANNEX 2 (1610.6 -1613.8 MHZ)

The technical discussion in this Annex 2 supports CSSMA's position set forth in Section III.C.3 of CSSMA's Comments to the *Smallsat NPRM*.

Below CSSMA shows that small satellite system characteristics can be made to be compatible with MSS users using the Globalstar system, RAS operators, and RNSS operators. Finally, it shows how small satellite operators can share this band among themselves. CSSMA addresses these points in the order mentioned.

1) <u>Compatibility with Globalstar</u>

Globalstar operates its system RETURN link in the lower half of the frequency band from 1610.0-1626.5 MHz. CSSMA focuses in this discussion on the Globalstar system and not the Iridium system as Iridium does not use this sub-band. Globalstar's system uses code-division multiple access ("CDMA") technology, employing an air interface standard quite similar to the (now obsolete) IS-95 cellular standard.[123] The system uses the subject spectrum as a portion of the RETURN direction user service links. Each satellite is capable of operating on thirteen frequency division multiplexed channels ("FDMs"). Each FDM is 1.23 MHz in bandwidth.[124] Within each FDM, multiple CDMA signals can occupy the same frequency channel simultaneously. Theoretically, 128 orthogonal CDMA voice (or low-speed data) users can share the same FDM in the FORWARD downlink.[125] In the downlink (2483.5-2491.75 MHz), operators make use of orthogonal code division multiple access ("OCDMA"), which has superior orthogonality characteristics;[126] however, the RETURN link cannot benefit from this technology due to issues associated with timing errors resulting from signals arriving from disparate user positions to

---

[123] *See generally* Schiff *et al.*, *Design and system operation of Globalstar versus IS-95 CDMA – similarities and differences*, Wireless Networks 6, 47-57 (2000).
[124] *See Description of the Globalstar System*, Globalstar at 3-4 (Dec. 7, 2000), https://gsproductsupport.files.wordpress.com/2009/04/description-of-the-globalstar-system-gs-tr-94-0001-rev-e-2000-12-07.pdf ("*Globalstar Overview*").
[125] *See id.* at 4-5.
[126] *See id.* at 3-19.

each satellite. On the RETURN link, which includes the subject band, it is possible to share the uplink CDMA system with as many as sixty-four users sharing the same FDM. Both advanced forward error correction ("FEC") coding and the use of RAKE receiver technology (signals constructively adding in two to three satellites relaying each signal) enhance the performance of this Earth-to-space link significantly.[127]

CSSMA believes that there is a simple means available to share spectrum with the Globalstar system in the RETURN link band as proposed by the Commission. The method would be as follows.

a) Small satellite Earth stations, as suggested in the *Smallsat NPRM*, would use directive antennas. A typical small satellite Earth station, for instance, might use a dish as small as 1.9 m, having a gain of approximately 27.5 dBi and a -3 dB beamwidth of 6.8°.

b) Small satellite systems would use a low EIRP setting in such a manner that the PFD level at a Globalstar satellite would be no larger than the largest amplitude CDMA uplink signal that would be encountered by one of its own hand-held earth terminals. As the Globalstar orbit at 1414 km is more than two times higher in altitude than the orbits being discussed for small satellite systems operated under the proposed licensing scheme,[128] the signal strength from small satellite Earth stations reaching small satellite space stations would be from 6 to 8 dB higher in PFD than those signals reaching Globalstar satellites (on average).

c) CSSMA proposes that the small satellite systems operating under the Streamlined Process would adopt an air interface essentially identical to that used by Globalstar.

i) The emission bandwidth would be identical (1.23 MHz).

ii) The emission multiplexing method would be CDMA.

iii) The chipping rate would be the same at 1.2288 Mcps.[129]

[127] *See id.* at 1-8; 4-2.
[128] *See id.* at 3-15.
[129] *See*, *e.g.*, *id.* at 4-9.

iv) The small satellite channelization plan would match that of the Globalstar system.[130]

v) It may be appropriate to adopt the same spreading code methods adopted by Globalstar; however, it would need to be reviewed.

The adoption of this air interface has many advantages, which are explained below.

If small satellite Earth stations use directive antennas as per a) above, in-line events that could potentially cause harmful interference to the Globalstar system would be minimized. The time of occurrence of in-line events could then be forecasted using traditional ITU-R tools.[131] Using predictive software could further reduce the impact of an in-line event by having the small satellite operator cease transitions during a conjunction. There will always be a smaller number of uplinking small satellite stations in comparison to the number of omni Globalstar subscriber terminals operating with that system.

When an in-line event does occur, the level of interference and its PFD should be adjusted to "appear" to the Globalstar satellite to be equal to one of the sixty-four CDMA signals accessing any one of the individual FDMs. In fact, Globalstar uses power control in both link directions. As the small satellite terminal does not share in this power control process, the signal strength from the small satellite Earth station could be several dB higher than the average signal strength of one subscriber signal at the Globalstar satellite. Hence, the interference could appear to be as large as several Globalstar subscriber terminals during the conjunction event (which will last a few seconds). Given the "look-alike" nature of the proposed small satellite signal, this circumstance would appear to the Globalstar satellite to be just the same as several additional users occupying the FDM (out of sixty-four) in terms of adjacent code noise. As the RETURN link of Globalstar uses the RAKE receiver concept, the second and third Globalstar satellites in simultaneous view would also retransmit the subscriber signal, which has been affected at the

[130] *See id.* at 3-4. The Commission would ultimately allocate to small satellite operations those FDM channels (among the 7-13 frequency channels).
[131] *See*, *e.g.*, *ITU-R and Transfinite Systems*, Transfinite Systems, https://www.transfinite.com/content/itu1, (Visualyse) (last visited July 6, 2018).

first victim satellite. But, this same signal will not be similarly affected as it passes through the alternate satellites; hence, the interference impact will be even smaller.

CSSMA realizes that its proposed scheme is a sophisticated approach and that it must be subjected to more rigorous analysis; however, it believes that such a method, with the adjustment of various parameters as discussed here, could allow for complete protection of the Globalstar system.

2) Protection of the RAS

It is most important that small satellite operations protect these critical "silent sites" from interference. In the *Smallsat NPRM*, the Commission suggests at least one method, which is to apply certain exclusion zones in favor of United States RAS sites, minimizing interference from small satellite Earth stations to RAS receivers. CSSMA agrees with this recommendation.

CSSMA believes that further protection would be afforded to the RAS if small satellites were allowed to use several of the Globalstar channels located above the top of the RAS band at 1613.8 MHz. In this event, the potential for interference to RAS sites would not only be reduced by not allowing Earth stations within the exclusion zone, but additionally, any potential interference would be only adjacent channel interference. CSSMA notes that the Globalstar waveform (which, by design, would be very similar to small satellite emission characteristics), rolls off very quickly away from the carrier. In addition, by using directive antennas (with some minimum specified elevation angle), any regional terrestrial Earth station interference could be reduced by the antenna roll-off factor.

CSSMA further notes that using a CDMA waveform may reduce PFD levels even further so long as RAS receiver bandwidths are narrower than the 1.23 MHz bandwidth used by this particular form of CDMA. The primary spectral line being observed at 1612.0 MHz is 20 kHz in bandwidth for instance.[132] Using CDMA in this example would reduce the PFD level by an additional 18 dB.

---

[132] *See Protection criteria used for radio astronomical measurements*, Recommendation ITU-R RA.769-2, Appendix A, Table 2 (2003).

Of these different methods, CSSMA believes the use of Globalstar channels above the cut-off frequency of 1613.8 MHz for terrestrial transmitting small satellite Earth stations would likely be the most effective methodology.

3) <u>Protection of RNSS</u>

CSSMA believes the emission levels (EIRP densities) identified in the *<u>current version</u>* of Section 25.216 (c) could be acceptable as a condition for operation by small satellite operators.[133] To be clear, CSSMA's interpretation of this section is that small satellite Earth station emissions must not exceed -70 dBW/MHz over any two-millisecond active transmission interval. Once again, CSSMA would benefit further from the adoption of the Globalstar air interface as the roll-off of CDMA emissions is very rapid out of band.

4) <u>Sharing Among Small Satellite Operators within the Band 1610.6 – 1613.8 MHz</u>

CSSMA observes, based on its previous comments, that sharing among small satellite operators would work just as well in the remainder of the 1613.8-1626.5 MHz band as it would within the subject band. Once the CDMA air interface is adopted by small satellite operators, sharing among small satellite operators would be essentially the same as sharing with Globalstar space stations. In-line interference events would be rare and of very short duration, and the interference levels, in this case, would be the same as having two (and only two) CDMA signals attempting to code share on the same channel, meaning there would be no interference to either satellite even during an in-line event.

However, there is another major benefit of the Globalstar CDMA air interface when it is used by small satellite operators with different sized systems. The CDMA spreading code used by the Globalstar system is multiplied by another code called a Walsh function.[134] In the RETURN, Earth-space link direction, user signals cannot be truly "orthogonal" to one another as they are on the FORWARD link. Coherent Walsh Coding reduces adjacent code noise by nearly 20 dB. However, the Walsh codes, when

---

[133] *See* 47 CFR § 25.216(c).
[134] *See, e.g., Globalstar Overview* at 4-8.

multiplied with the spreading code still allows the effective data rate to be modified in accordance with the formula.

$$W/N = R$$

Where:

W = Spreading sequence chipping rate (1.2288 Mbps)

N = the Walsh code length (typically 32 to 9600 bits)

R = the end user data rate (typically 38,400 bps to 300 bps)

And, even though on this RETURN path, the chips cannot be aligned closely enough to allow orthogonal co-channel operation, it is possible to use the property of Walsh Codes, which allows the factor of $1/2^n$ data rate adjustment to function properly.

The final added benefit is that the uplink power required to close the link is inversely proportional to the data rate just as it is in narrowband, non-CDMA systems. All users would operate with the same bandwidth, have identical uplink chipping rates, and use identical equipment. However, a user with a 32-bit Walsh Code would achieve a data rate of 38.4 kbps and might use an uplink EIRP of 10 watts. A user with a 1024-bit Walsh Code, however, would achieve a data rate of only 1200 bps, yet this user would require a transmission system with an EIRP of only 0.313 watts. Hence, small satellite operators using the same equipment otherwise would use the same bandwidth but would use only a small fraction of the transmitter power, reducing this class of operator's PFD by -15 dB (10Log(1/32)) in comparison with the higher data rate operators.